10-2016

The US Transit Bus Manufacturing Industry

David Czerwinski
San Jose State University, david.czerwinski@sjsu.edu

Xu (Cissy) Hartling
Salem State University

Jing Zhang
San Jose State University, jing.zhang@sjsu.edu

MINETA TRANSPORTATION INSTITUTE

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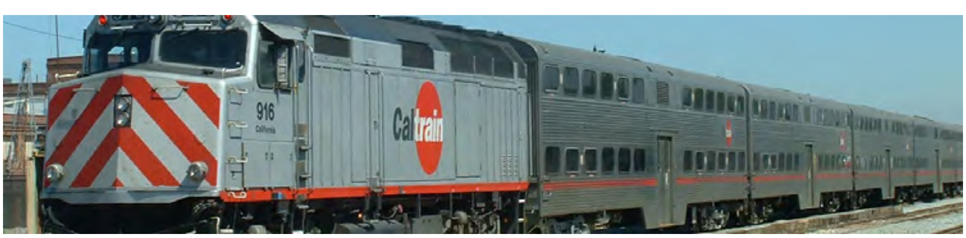
MTI Report 12-66



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REPORT 12-66

THE US TRANSIT BUS MANUFACTURING INDUSTRY

David Czerwinski, Ph.D.
Xu (Cissy) Hartling, Ph.D.
Jing Zhang, Ph.D.

October 2016

A publication of
Mineta Transportation Institute
Created by Congress in 1991

College of Business
San José State University
San José, CA 95192-0219

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. CA-MTI-16-1234	**2. Government Accession No.**	**3. Recipient's Catalog No.**
4. Title and Subtitle The US Transit Bus Manufacturing Industry		**5. Report Date** October 2016 **6. Performing Organization Code**
7. Authors David Czerwinski, Ph.D., Xu (Cissy) Hartling, Ph.D., and Jing Zhang, Ph.D.		**8. Performing Organization Report** MTI Report 12-66
9. Performing Organization Name and Address Mineta Transportation Institute College of Business San José State University San José, CA 95192-0219		**10. Work Unit No.** **11. Contract or Grant No.** DTRT12-G-UTC21
12. Sponsoring Agency Name and Address California Department of Transportation Division of Research, Innovation and Systems Information MS-42, PO Box 942873 Sacramento, CA 94273-0001	U.S. Department of Transportation Office of the Assistant Secretary for Research and Technology University Transportation Centers Program 1200 New Jersey Avenue, SE Washington, DC 20590	**13. Type of Report and Period Covered** Final Report **14. Sponsoring Agency Code**
15. Supplemental Notes		

16. Abstract

Manufacturing buses for the US transit market has been a challenging business over the last several decades. It is a small market with volatile demand. Many manufacturers have gone bankrupt, left the market, or been acquired by competitors. Manufacturers of transit buses in the US must comply with a wide range of operational and design regulations. The most salient policy areas include regulating emissions, disabled access, procurement, alternative fuels, the Altoona Test, pooled purchases and piggybacking, spare ratios, workforce training, minimum useful life, Buy America, and research & development (R&D). The purpose of this report is to provide policy makers with an update on the state of the industry, an analysis of how government policies are impacting the industry, and suggestions for policies that can help the industry move forward and thrive to best serve the transit-riding public.

17. Key Words Transit; bus; bus manufacturing; transit funding; transit policy	**18. Distribution Statement** No restrictions. This document is available to the public through The National Technical Information Service, Springfield, VA 22161		
19. Security Classif. (of this report) Unclassified	**20. Security Classif. (of this page)** Unclassified	**21. No. of Pages** 79	**22. Price** $15.00

Form DOT F 1700.7 (8-72)

Library of Congress Catalog Card Number:
2016955392

To order this publication, please contact:

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Tel: (408) 924-7560
Fax: (408) 924-7565
Email: mineta-institute@sjsu.edu

transweb.sjsu.edu

101316

ACKNOWLEDGMENTS

The investigators would like to acknowledge the following companies and transit agencies for their participation in this study. This report would not have been possible without the interviewees' generosity with their time and willing-ness to share their perspectives on the transit bus manufacturing industry.

- BYD
- Chicago Transit Authority
- Complete Coach Works
- Cummins
- Dallas Area Rapid Transit
- Des Moines Area Regional Transit Authority
- Gillig
- New York City Transit
- Proterra
- SamTrans
- TriMet

The researchers thank the anonymous referees for their careful reading of the draft report and for their insights and thoughtful feedback, which greatly improved the final product.

The authors also thank MTI staff, including Executive Director Karen Philbrick, Ph.D.; Publication Support Coordinator Joseph Mercado; Executive Administrative Assistant Jill Carter; and Editor and Webmaster Frances Cherman.

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EXECUTIVE SUMMARY

Manufacturing buses for the US transit market has been a challenging business over the last several decades. It is a small market with volatile demand. Over the twenty-year period 1995-2014, annual spending on buses by US transit agencies has swung between extremes of $1.4 billion and $3.1 billion[1] (in 2014 dollars[2]).

Many manufacturers have gone bankrupt, left the market, or been acquired by competitors. Only three major transit bus manufacturers remain serving the heavy-duty transit bus market and a similar number serve the market for small- to mid-sized transit buses.

The purpose of this report is to provide policy makers with an update on the state of the industry, an analysis of how government policies are impacting the industries, and suggestions for policies that can help the industry move forward and thrive to best serve the transit-riding public.

Buses are the workhorses of public transit in the US. Buses provide more rides annually than all other public transit modes combined. Over 5.3 billion unlinked transit trips were taken on buses in 2014, accounting for 50% of all trips on transit.

Manufacturers of transit buses in the US must comply with a wide range of operational and design regulations. The most salient policy areas include regulating emissions, disabled access, procurement, alternative fuels, the Altoona Test, pooled purchases and piggybacking, spare ratios, workforce training, minimum useful life, Buy America, and research & development (R&D).

To ensure a thriving transit bus manufacturing industry that continues to improve product quality, invests in R&D, and best serves the riding public, policy makers should:

- Work to ensure long-term funding.
- Think carefully about whether making transit buses take the lead for clean-air regulations is a public policy that advances the nation's environmental quality.
- Continue to support experimentation with and adoption of alternative fuels.
- Facilitate an industry-wide conversation around standardization of battery-electric charging infrastructure. Implement policies so that transit agencies aren't penalized financially for adopting battery-electric technology.

I. INTRODUCTION

Manufacturing buses for the US transit market has been a challenging business over the last several decades. It is a small market with volatile demand. Over the twenty-year period 1995-2014, annual spending on buses by US transit agencies has averaged just over $2.3 billion[3] (adjusted for inflation[4]). However, the amount has swung dramatically over the years. From $1.4 billion in 1995, annual spending grew to $3.1 billion in 2001, only to fall back down to $1.8 billion by 2005. Spending grew again and then held relatively stable between 2009 and 2012 at the $2.9 billion level. Spending fell to $2.4 billion in 2013, recovering somewhat in 2014 to $2.6 billion

Manufacturers have gone bankrupt, left the market, or been acquired by competitors. Only three major manufacturers remain serving the heavy-duty transit bus market and a similar number account for most of the market for small- to mid-sized transit buses.

The purpose of this report is to provide policy makers with an update on the state of the industry, an analysis of how government policies are impacting the industries, and suggestions for policies that can help the bus manufacturing industry move forward and thrive to best serve the transit-riding public.

The research methodology for the report consisted of a literature review, interviews with industry experts, and an analysis of data from the Federal Transit Administration's (FTA) National Transit Database (NTD) and the American Public Transportation Association (APTA). The literature review was conduct primarily through Transportation Research Board's TRID system, Google Scholar, and Lexis/Nexis. To arrange the expert interviews the investigators contacted transit agencies, manufacturers, and suppliers by e-mail. A range of transit agencies was contacted to provide representation of transit agencies from different geographic regions within the US and of different sizes. Semi-structured interviews were conducted by phone between July 2014 and January 2016. Six transit agencies, four manufacturers, and one supplier participated. Data analysis of the NTD and APTA data was performed in R and in Excel.

The report is organized as follows. In Section II the authors provide an overview of bus transit service in the US. In Section III the investigators detail the latest transit bus manufacturing data and recent trends. Section IV examines current practices and trends in bus procurement and funding. Section V explains the government policies that affect the industry and relates our interviewees' perspectives on these issues. Section VI compares the transit bus industry with other industries to gain insights from their similarities and differences. Lastly, Section VII synthesizes the findings from the other sections and presents a set of proposals to guide policy makers.

II. US BUS TRANSIT SERVICE

TRANSIT BUS SERVICE OVERVIEW

Buses are the workhorses of public transit in the US. Buses provide as many rides annually as all other public transit modes combined. Over 5.3 billion unlinked† transit trips were taken on buses in 2014 (50% of all unlinked trips), the most recent year for which data is available (Table 1). Bus ridership declined for three years following the 2008 financial crisis before leveling off in 2011 (Figure 1).

Table 1. 2014 Passenger Trips, Passenger Miles, and Average Trip Length by Mode

Mode	Passenger Trips (Millions)	Percent	Passenger Miles (Millions)	Percent	Average Trip Length (Miles)
All Bus[a]	5,370	50%	22,614	38%	4.2
Commuter Rail	490	5%	11,718	20%	23.9
Demand Response	233	2%	2,267	4%	9.7
Heavy Rail	3,928	37%	18,339	31%	4.7
Light Rail	483	4%	2,490	4%	5.2
Other[b]	247	2%	2,216	4%	9.0
Total	10,751	100%	59,644	100%	5.5

Source: 2016 APTA Fact Book Appendix A: Historical Tables.

[a] The "All Bus" category includes the NTD modes Bus, Bus Rapid Transit, Commuter Bus, and Trolleybus.

[b] Other includes NTD modes Ferryboat, Hybrid Rail, Aerial Tramway, Automated Guideway Transit, Cable Car, Inclined Plane, Monorail, Publico, Streetcar, and Transit Vanpool. Each individually accounts for less than 1% of all passenger trips.

Bus service is operated broadly across the US. Over 1,100 transit agencies provide bus service (Table 2). Service is provided in a wide range of settings: rural areas and small towns, small cities, large cities and their suburbs.

† An "unlinked" trip involves a passenger boarding a single vehicle. For example, if a person rides one bus and then transfers to another bus to complete their journey that would be counted as two unlinked trips (regardless of whether they pay an additional fare when transferring).

Table 2. Number of Agencies Operating Transit Modes, 2014

Mode	Agencies[c]
Bus	1,087
Bus Rapid Transit	11
Commuter bus	268
Commuter rail	27
Demand response	6,370
Ferryboat	41
Heavy rail	15
Hybrid rail	5
Light rail	23
Publico	1
Streetcar	11
Transit Vanpool	99
Trolleybus	5
Other Fixed-Guideway Modes[d]	16

Source: 2016 APTA Fact Book Appendix A: Historical Tables.

[c] Agencies that operate more than one mode of service are included in the count for each type of service they operate.

[d] Other Fixed-Guideway Modes includes aerial tramway, automated guideway transit, cable car, inclined plane, and monorail.

A variety of different types of bus services are provided in the US. Conventional bus service is most common and consists of rubber-tired vehicles operating on a road, following a fixed route and schedule or other regular pattern.[5,6]

A trolleybus operates in a similar manner but is powered by electricity drawn from overhead wires.[†] Trolleybus fleets are operated in Boston and its suburbs, Dayton (OH), Philadelphia, San Francisco, and Seattle.

Bus rapid transit (BRT) involves enhancements to provide fast, high-capacity service with a more rail-like atmosphere and amenities. BRT service may include bus stops spaced further apart, a dedicated right of way along some or all of the route, boarding platforms level with the floor of the vehicle, signal priority at intersections, and prepaid boarding. The bus itself may have a higher capacity, more doors to speed up boarding and alighting, and distinctive styling.[7,8]

Commuter bus service carries commuters into the central business district from distant suburbs or neighboring cities. A commuter bus picks passengers up at one or more stops near the beginning of the route and then operates express without stops for at least five miles.[9] Whereas the average trip length on a conventional bus route is 3.8 miles, the average trip length on a commuter bus is 27.3 miles.[10]

[†] As the focus of this report is bus manufacturing, the authors include trolleybuses since they are manufactured by the same companies as standard diesel buses.

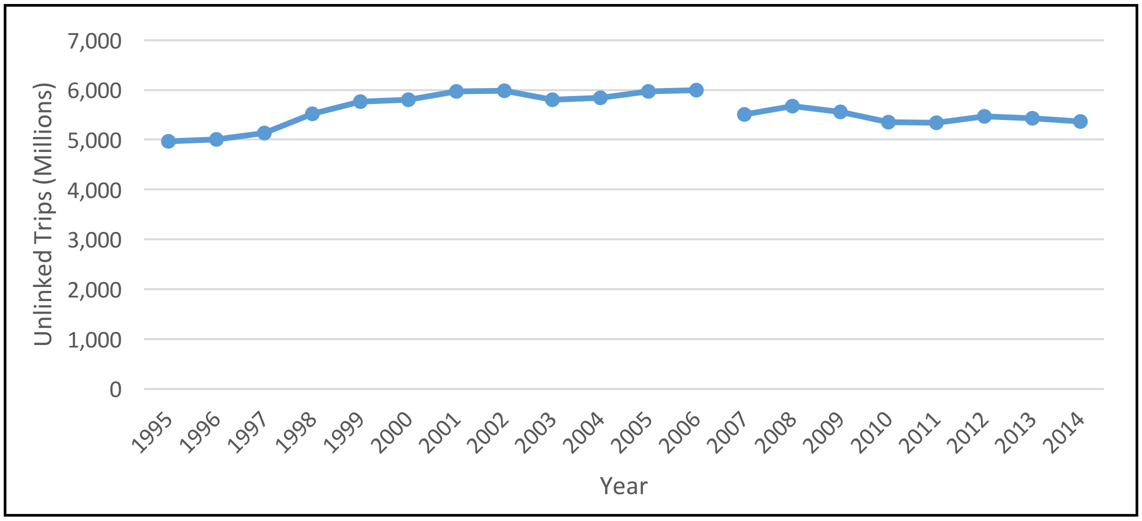

Figure 1. Annual Unlinked Bus Trips, 1995 – 2014

Source: 2016 APTA Fact Book Appendix A: Historical Tables.

Note: A change in reporting for rural transit ridership occurred in 2007. This results in a discontinuity in the ridership data between 2006 and 2007 because of the way rural bus ridership was previously estimated.

Transit buses also come in a variety of sizes. The standard heavy-duty transit bus is 40 feet long, but smaller and larger buses are also common. 30-foot and 35-foot buses are used on lighter ridership routes or routes that are difficult for a larger bus to maneuver on. Buses smaller than 30 feet are used as well, particularly on shuttle routes. Larger buses include 45-foot buses as well as 60-foot articulated buses that have “accordion” sections in the middle.

The FTA categorizes buses according to size as shown in Table 3. Along with its length, a bus’s size can be characterized by its Gross Vehicle Weight (GVW), which is the combined weight of the bus and its passenger load at full capacity. The FTA requires that buses purchased with federal funds meet the minimum useful life requirements shown in Table 3.

Table 3. FTA Bus Categories

Category	Length (in Feet)	Approximate GVW (in Pounds)	Minimum Useful Life
Large-size, heavy-duty	35+	33,000 to 40,000	12 years/500,000 miles
Small-size, heavy-duty	30	26,000 to 33,000	10 years/350,000 miles
Medium-size, medium-duty	25 to 35	16,000 to 26,000	7 years/200,000 miles
Medium-size, light-duty	25 to 25	10,000 to 16,000	5 years/150,000 miles
Other light-duty		6,000 – 4,000	4 years/100,000 miles

Sources: FTA Circular 5010.1D, Laver et al. “Useful Life of Transit Buses and Vans.”

Commensurate with the amount of service buses provide in the US, they also account for approximately half of public transit operating costs (Table 4). In 2014, the operating cost for bus service was $20.6 billion. Approximately 200,000 employees were involved in providing bus service. In large urban areas with populations over one million, buses account for 47% of operating costs. In urban areas with populations between 200,000 and one million, buses account for 73% of operating costs, and in urban areas with fewer than 200,000 people buses account for 72% of operating costs. The higher prevalence of rail service in larger urban areas accounts for these differences.

Table 4. 2014 Operating Cost and Employees by Mode

Mode	Operating Cost (Millions)	Percent	Employees	Percent
All Bus[e]	21,664.2	49%	197,257	49%
Commuter Rail	5,748.7	13%	29,602	7%
Demand Response	5,332.3	12%	103,387	26%
Heavy Rail	8,648.3	19%	52,721	13%
Light Rail	1,746.2	4%	11,963	3%
Other[f]	1,305.2	3%	8,047	2%
Total	44,444.9	100%	402,977	100%

Source: 2016 APTA Fact Book Appendix A: Historical Tables.

[e] All Bus includes the NTD modes Bus, Bus Rapid Transit, Commuter Bus, and Trolleybus.

[f] Other includes NTD modes Ferryboat, Hybrid Rail, Aerial Tramway, Automated Guideway Transit, Cable Car, Inclined Plane, Monorail, Streetcar, and Transit Vanpool. Publico is included in the Operating Cost column but not in the Employees column (data not reported).

The cost-effectiveness of public transit modes can be analyzed in a number of ways. Table 5 presents the cost per trip and the cost per passenger mile for the different modes of transit (based on operating costs). On average, it costs $4.03 to provide a passenger trip on bus, which is more expensive than heavy rail and light rail but less expensive than commuter rail and demand response. Because bus trips are shorter on average than trips on other modes (see Table 1), the cost per passenger mile on bus ranks second highest after demand response.

Table 5. 2014 Cost per Trip and Passenger Mile by Mode

Mode	Cost per Trip	Cost per Passenger Mile
All Bus[e]	$4.03	$0.96
Commuter Rail	$11.73	$0.49
Demand Response	$22.89	$2.35
Heavy Rail	$2.20	$0.47
Light Rail	$3.62	$0.70
Other[f]	$5.28	$0.59
Average	$4.13	$0.75

Source: 2016 APTA Fact Book Appendix A: Historical Tables.

[e] All Bus includes the NTD modes Bus, Bus Rapid Transit, Commuter Bus, and Trolleybus.

[f] Other includes the APTA categories Ferryboat, Hybrid Rail, Publico, Streetcar, Transit Vanpool, and Other Fixed-Guideway.

In 2014, public transit agencies spent $2.6 billion to purchase buses (Table 6). Figure 2 shows the trend of annual spending on buses between 1995 and 2014. Spending has been quite variable due to the underlying variability in federal funding. Over the twenty-year period, annual spending on buses by US transit agencies has averaged just over $2 billion[11] (in 2014 dollars). However, the amount has swung dramatically over the years. From an inflation-adjusted $1.4 billion in 1995, annual spending grew to $3.1 billion in 2001, only to fall back down to $1.8 billion by 2005. In 2009 spending again returned to the $2.8 billion level.

Table 6. 2014 Expenditures for Passenger Vehicles

Mode	Expenditures for Passenger Vehicles ($ Millions)	Percent
All Bus[g]	2,572	52%
Commuter Rail	676	14%
Demand Response	394	8%
Heavy Rail	687	14%
Light Rail[h]	351	7%
Other[i]	265	5%
Total	4,945	100%

Source: 2016 APTA Fact Book: Appendix A.

[g] The "All Bus" category includes the NTD modes Bus, Bus Rapid Transit, Commuter Bus, and Trolleybus.

[h] Includes streetcar expenditures.

[i] Other includes NTD modes Ferryboat, Hybrid Rail, Aerial Tramway, Automated Guideway Transit, Cable Car, Inclined Plane, Monorail, and Transit Vanpool.

Figure 2 also shows the long-term federal surface transportation funding authorizations in effect over the time period. The Intermodal Surface Transportation Efficiency Act (ISTEA), which went into effect in 1992, was in effect through 1997. It was extended once for six months before the Transportation Equity Act for the 21st Century (TEA-21) succeeded it.[12] TEA-21 was in effect from 1998 through 2003. Between 2003 and 2005 twelve short-term extensions were made to TEA-21.[13] As can be seen in Figure 2, spending on buses fell precipitously by 34% between 2004 and 2005 as a result.

In 2005, the Safe, Accountable, Flexible, Efficient Transportation Equity Act – A Legacy for Users (SAFETEA-LU) went into effect, providing funding through 2009. At its expiration, again there was a delay before the passage of a successor long-term surface transportation-funding bill. SAFETEA-LU was extended ten times over the course of three years.[14,15] During this time, bus expenditure levels held steady, as seen in Figure 2.

Subsequently, the Moving Ahead for Progress in the 21st Century Act (MAP-21) provided two years of surface transportation spending authorization, for 2013 and 2014.[16] It was extended five times through 2015 before the passage of the Fixing America's Surface Transportation Act (FAST Act). The FAST Act is discussed further in Chapter IV.

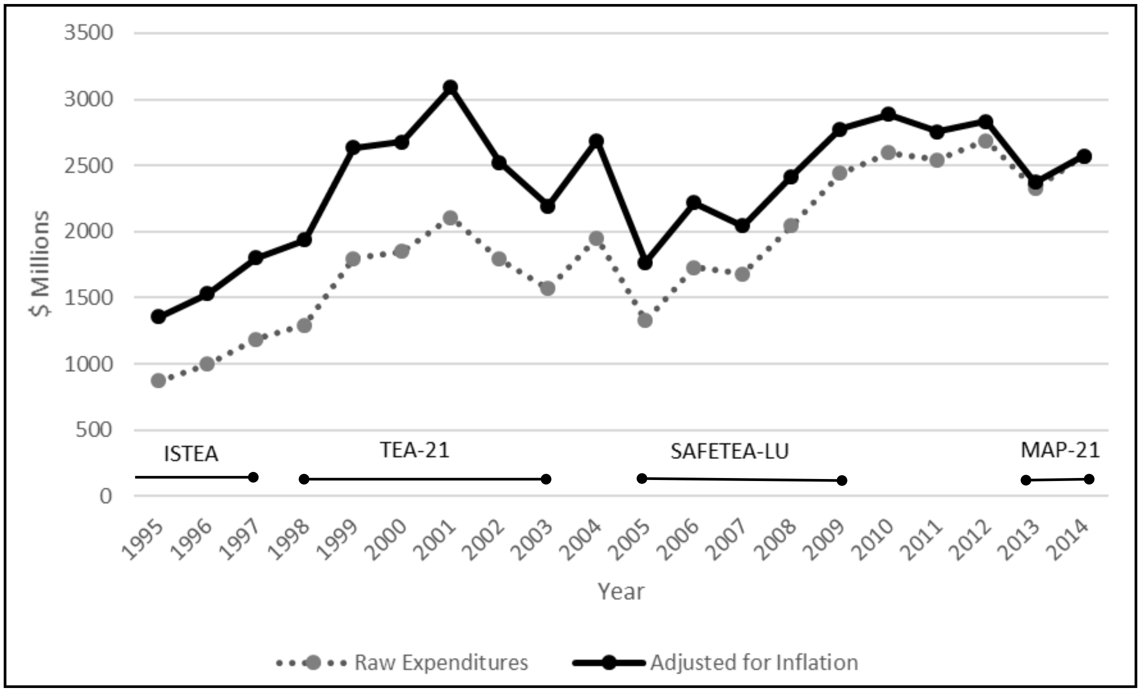

Figure 2. Annual Expenditure on Buses, 1995 – 2014

Source: APTA Transportation Fact Books, 1997 – 2004, 2016 APTA Fact Book Appendix A: Historical Tables. *Federal surface transportation funding authorizations in effect at the time are shown above the horizontal axis. Expenditures are in 2014 dollars, adjusted based on the Bureau of Labor Statistics Producer Price Index for Heavy Duty Truck Manufacturing (PCU3361203361202).*

The age of the US transit bus fleet has also fluctuated over the last two decades. Figure 3 shows that the average age of the US transit bus fleet declined between 1995 and 2004 before climbing beginning in 2005 and leveling off around 2009. Comparing Figures 2 and 3 shows the effect that spending on buses has on the age of the fleet. When spending grew between 1995 and 2001, fleet age declined. The sharp decrease in spending in 2005 marked the turning point from a decreasing fleet age to an increasing fleet age. Around 2009 both spending and fleet age leveled off.

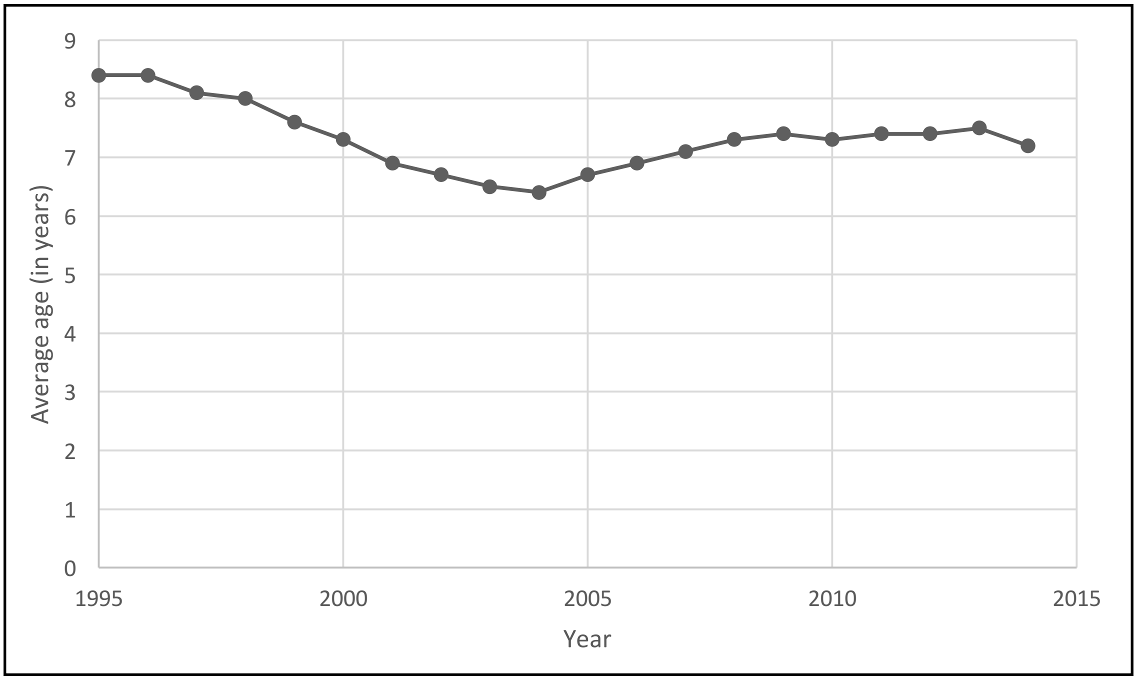

Figure 3. Average Age of US Transit Bus Fleet, 1995 – 2014

Source: FTA National Transit Summary and Trends 1998, FTA National Transit Summary and Trends 2005, FTA National Transit Summary and Trends 2014: Appendix.

III. VEHICLE PRODUCTION

According to an analysis of the 2014 National Transit Database, a total of 36 bus manufacturers built 4,696 transit buses in 2013 for the US market. As Table 7 and Figure 4 demonstrate, bus production fluctuated during the six-year period from 2008 to 2013. Compared to 2012, total production decreased by 19% in 2013. The total production did increase in 2010 and 2012 by 14% and 20% respectively. However the current bus production is still below the 2008 total production level of 6,027.

In 2013, the following four manufacturers produced 3,171 buses, accounting for approximately 68% of total transit bus production:

- Gillig Corporation
- New Flyer Industries
- North American Bus Industries Inc.
- ElDorado National

Table 7. Transit Bus Production 2008-2013 by Manufacturer[I]

Manufacturer	2008	2009	2010	2011	2012	2013
Gillig Corporation	1,182	1,448	1,401	1,177	1,332	1,537
New Flyer Industries	428	732	928	755	942	878
North American Bus Industries Inc.	430	272	456	343	682	402
ElDorado National	413	222	511	66	446	354
Glaval Bus	69	68	92	29	229	169
Coach and Equipment Manufacturing Company	70	73	27	9	100	161
Starcraft	129	18	63	15	264	142
Ford Motor Corporation	486	435	596	55	54	135
Champion Motor Coach Inc.	29	35	97	29	149	132
Goshen Coach	124	270	80	40	187	112
Others	2,667	1,345	1,341	2,300	1,418	674
Total	**6,027**	**4,918**	**5,592**	**4,818**	**5,803**	**4,696**
		-18%	14%	-14%	20%	-19%

Source: 2009-2014 National Transit Database.

[I] Quantities only reflect production for reported public transit agencies in urbanized areas. In each reporting year, the detailed annual production data from the preceding year is obtained.

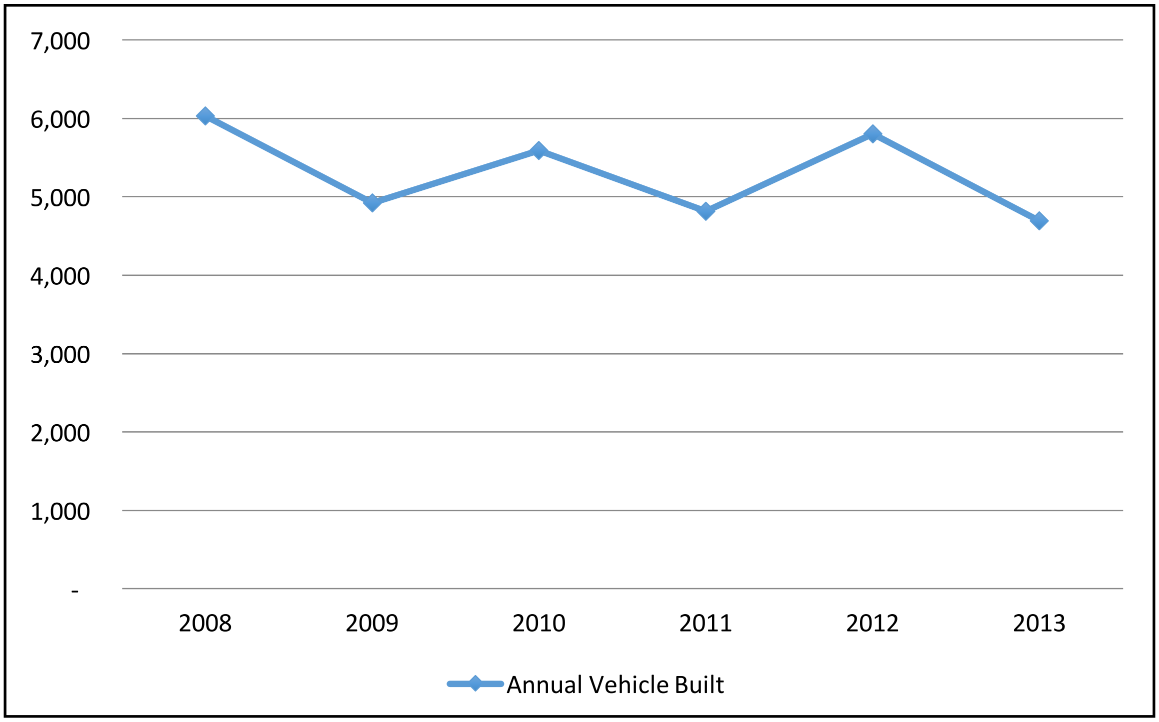

Figure 4. Transit Bus Production 2008 – 2013

Source: 2009-2014 National Transit Database.

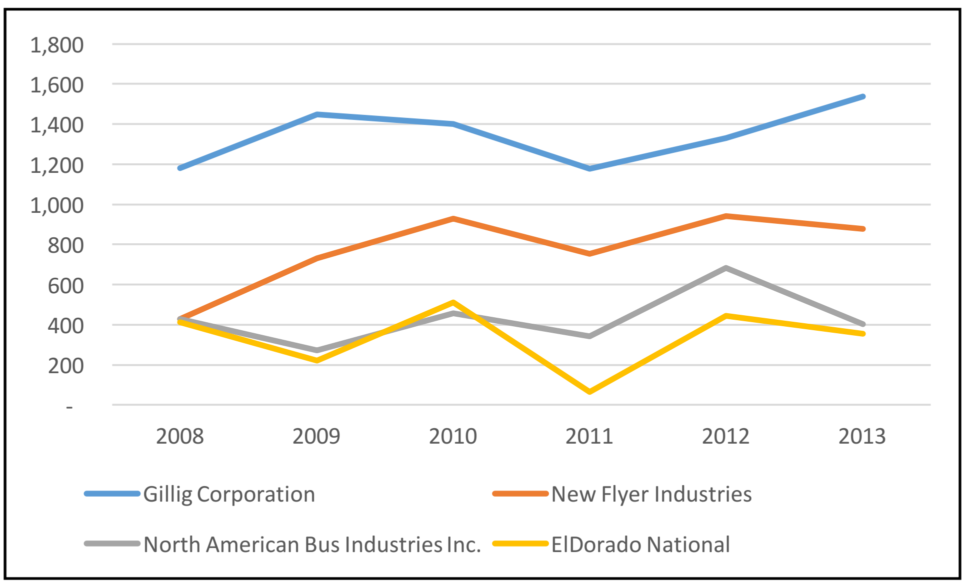

Figure 5. Transit Bus Production 2008 – 2013 by Manufacturer

Source: 2009-2014 National Transit Database.

As shown in Figure 5, Gillig built the largest number of transit buses in 2013 – a total of 1,537 buses, representing approximately 33% of the total production that year. New Flyer was second in terms of bus production in 2013, followed by North American Bus Industries (NABI) and ElDorado National.

In 2013, Gillig's bus production increased by 15%, but the other three manufacturers all experienced production decreases. In 2012, the production of all four manufacturers increased. It is notable that NABI almost doubled its total production. ElDorado National experienced significant growth in 2012 (5.8 times). The remaining two increased their production by 13% (Gillig) to 25% (New Flyer).

In the next section, the authors will review production of the most commonly produced vehicle types: 30-ft., 35-ft., 40-ft., and 60-ft. transit buses.

Vehicle Types

40-ft. Transit Bus

Among the types of transit buses produced in the US, the 40-ft. transit bus represents the single largest production volume. Between 2008 and 2013, the four manufacturers built 10,480 40-ft. transit buses, which accounts for 60% of their total bus production during the period.

Gillig produced 993 40-ft. vehicles in 2013, which is approximately 52% of the total 40-ft. transit bus production that year. Production of 40-ft. transit buses by NABI reached its highest level in 2012 during the six-year period but experienced a slight decrease in 2013.

Table 8. 40' Transit Bus Production 2008 – 2013 by Manufacturer

Manufacturer	2008	2009	2010	2011	2012	2013
Gillig Corporation	688	881	894	670	941	993
New Flyer Industries	810	432	501	509	683	633
North American Bus Industries Inc.	241	144	311	303	478	273
ElDorado National	2	0	0	3	62	28
Totals:	1,741	1,457	1,706	1,485	2,164	1,927

Source: 2009-2014 National Transit Database.

Table 9. 40' Transit Bus Production 2008 – 2013 by Manufacturer as Percent of Total

Manufacturer	2008	2009	2010	2011	2012	2013
Gillig Corporation	39.52%	60.47%	52.40%	45.12%	43.48%	51.53%
New Flyer Industries	46.52%	29.65%	29.37%	34.28%	31.56%	32.85%
North American Bus Industries Inc.	13.84%	9.88%	18.23%	20.40%	22.09%	14.17%
ElDorado National	0.11%	0.00%	0.00%	0.20%	2.87%	1.45%

Source: 2009-2014 National Transit Database.

35-ft. Transit Bus

The production of 35-ft. transit buses is the second largest segment of bus production, although significantly less than that of 40-ft. buses. Between 2008 and 2013, the four bus manufacturers built 2,231 35-ft. transit buses, which accounts for 13% of their total bus production during the same period. However, the total production of 35-ft. transit bus had been decreasing during the period between 2008 and 2013 and it dropped to its lowest level in 2013.

Again, Gillig is the top manufacturer of 35-ft. transit buses. It produced 229 35-ft. vehicles in 2013, which is approximately 74% of total 35-ft. transit bus production that year. New Flyer steadily increased its production of 35-ft. transit buses from six in 2008 to 49 in 2013, while NABI's production decreased from 53 in 2008 to none in 2012 and 2013.

Table 10. 35' Transit Bus Production 2008 – 2013 by Manufacturer

Manufacturer	2008	2009	2010	2011	2012	2013
Gillig Corporation	276	334	295	361	247	229
New Flyer Industries	6	72	93	26	75	49
North American Bus Industries Inc.	53	8	8	2	-	-
ElDorado National	4	4	32	9	18	30
Totals:	339	418	428	398	340	308

Source: 2009-2014 National Transit Database.

Table 11. 35' Transit Bus Production 2008 – 2013 by Manufacturer as Percent of Total

Manufacturer	2008	2009	2010	2011	2012	2013
Gillig Corporation	81.42%	79.90%	68.93%	90.70%	72.65%	74.35%
New Flyer Industries	1.77%	17.22%	21.73%	6.53%	22.06%	15.91%
North American Bus Industries Inc.	15.63%	1.91%	1.87%	0.50%	0.00%	0.00%
ElDorado National	1.18%	0.96%	7.48%	2.26%	5.29%	9.74%

Source: 2009-2014 National Transit Database.

60-ft. Transit Bus

The 60-ft. articulated transit bus accounted for 2% of the total transit bus production in 2012, but the percentage dropped to 0.1% in 2013. There were only two manufacturers who produced them, New Flyer and NABI.

Both New Flyer and NABI had no production of 60-ft. buses in 2008 and 2009. New Flyer's production of 60-ft. buses reached its highest level in 2012, 97 vehicles, which represent 86% of the total 60-ft. bus production that year. In 2013, both manufacturers only produced three 60-ft. buses each, which represents significant reduction since 2010.

Table 12. 60' Transit Bus Production 2008 – 2013 by Manufacturer

Manufacturer	2008	2009	2010	2011	2012	2013
New Flyer Industries			20	12	97	3
North American Bus Industries Inc.			21	21	16	3
Totals:			41	33	113	6

Source: 2009-2014 National Transit Database.

Table 13. 60’ Transit Bus Production 2008 – 2013 by Manufacturer as Percent of Total

Manufacturer	2008	2009	2010	2011	2012	2013
New Flyer Industries			48.78%	36.36%	85.84%	50.00%
North American Bus Industries Inc.			51.22%	63.64%	14.16%	50.00%

Source: 2009-2014 National Transit Database.

30-ft. Transit Bus

There were 538 30-ft. transit buses produced between 2008 and 2013 by the four major manufacturers. Two manufacturers, Gillig and ElDorado National, were the primary producers. The total production of both manufacturers represented 58% of the total production of 30-ft. transit buses in 2012 and 100% in 2013. A few other manufacturers including Champion Motor Coach Inc., ElDorado Bus, and Freightliner Corporation also built this size bus.

Table 14. 30’ Transit Bus Production 2008 – 2013 by Manufacturer

Manufacturer	2008	2009	2010	2011	2012	2013
Gillig Corporation	32	67	96	42	55	42
New Flyer Industries	0	0	4	0	0	0
North American Bus Industries Inc.	7	3	1	0	0	0
ElDorado National	21	51	76	8	11	22
Totals:	62	121	177	52	71	64

Source: 2009-2014 National Transit Database.

Table 15. 30’ Transit Bus Production 2008 – 2013 by Manufacturer as Percent of Total

Manufacturer	2008	2009	2010	2011	2012	2013
Gillig Corporation	51.61%	55.37%	54.24%	80.77%	77.46%	65.63%
New Flyer Industries	0.00%	0.00%	2.26%	0.00%	0.00%	0.00%
North American Bus Industries Inc.	11.29%	2.48%	0.56%	0.00%	0.00%	0.00%
ElDorado National	33.87%	42.15%	42.94%	15.38%	15.49%	34.38%

Source: 2009-2014 National Transit Database.

Other Transit Buses

The total production of transit buses ranging from 20-ft. to 26-ft. was 1,335 in 2013, which accounts for approximately 28% of the total bus production that year. The largest manufacturer of 20–26-ft. transit bus is ElDorado National, which produced 21% of the total 20–26-ft transit buses in 2013. And in 2012, the total production was 1,924, which is approximately 33% of the total bus production. This category is 3.8 times of the total production of 35-ft. transit buses in 2013 and more than four times of the total production in 2012. In 2013, the total production in this category is only 32% less than the production of 40-ft. buses (the highest total volume).

Table 16. 20’ to 26’ Transit Bus Production in 2013

Manufacturer	20’	21’	22-ft.	23-ft.	24-ft.	25-ft.	26-ft.	Total
ElDorado National	3	0	105	2	30	49	13	202
Coach and Equipment Manufacturing Company	21	2	0	8	0	31	99	161
Starcraft	2	0	10	0	44	13	64	133
Glaval Bus	36	0	1	16	2	29	42	126
Ford Motor Corporation	30	0	14	19	41	14	2	120
Goshen Coach	4	0	7	13	44	23	20	111
Champion Motor Coach Inc.	13	0	12	47	0	37	0	109
Totals:	109	2	149	105	161	196	240	962

Source: 2009-2014 National Transit Database.

Vehicle Fuel and Propulsion Systems

Transit bus manufacturers provide a variety of fuel and propulsion systems. With the new technology development and demand change over time, fuel development changed over the years.

The most common fuel types provided in 2013 are listed below (in descending order). Their combined volume is approximately 99%.

- Diesel
- Compressed natural gas (CNG)
- Gasoline
- Hybrid diesel
- Liquefied Petroleum Gas

While the most common fuel types (over 99% of the total vehicles produced) provided in 2012 included (in descending order):

- Diesel
- Compressed natural gas (CNG)
- Gasoline
- Bio-diesel (BD)
- Hybrid diesel
- Dual fuel

Table 17 and Figure 6 summarize the production of different fuel types changes over the period of our study.

Table 17. Transit Bus Production 2008 – 2013 by Fuel Type

Fuel Type	2008	2009	2010	2011	2012	2013
Diesel	2,626	2,665	2,736	2,307	2,045	2,071
CNG	678	484	452	304	1,540	1,159
Gasoline	1,085	623	824	947	1,395	893
Hybrid diesel	262	572	740	844	327	417
LPG	23	30	22	5	10	94
Bio-diesel	452	288	528	335	399	0
Dual fuel	894	147	184	68	63	19
Percentage of total production	99.9%	97.8%	98.1%	99.8%	99.6%	99.1%

Source: 2009-2014 National Transit Database.

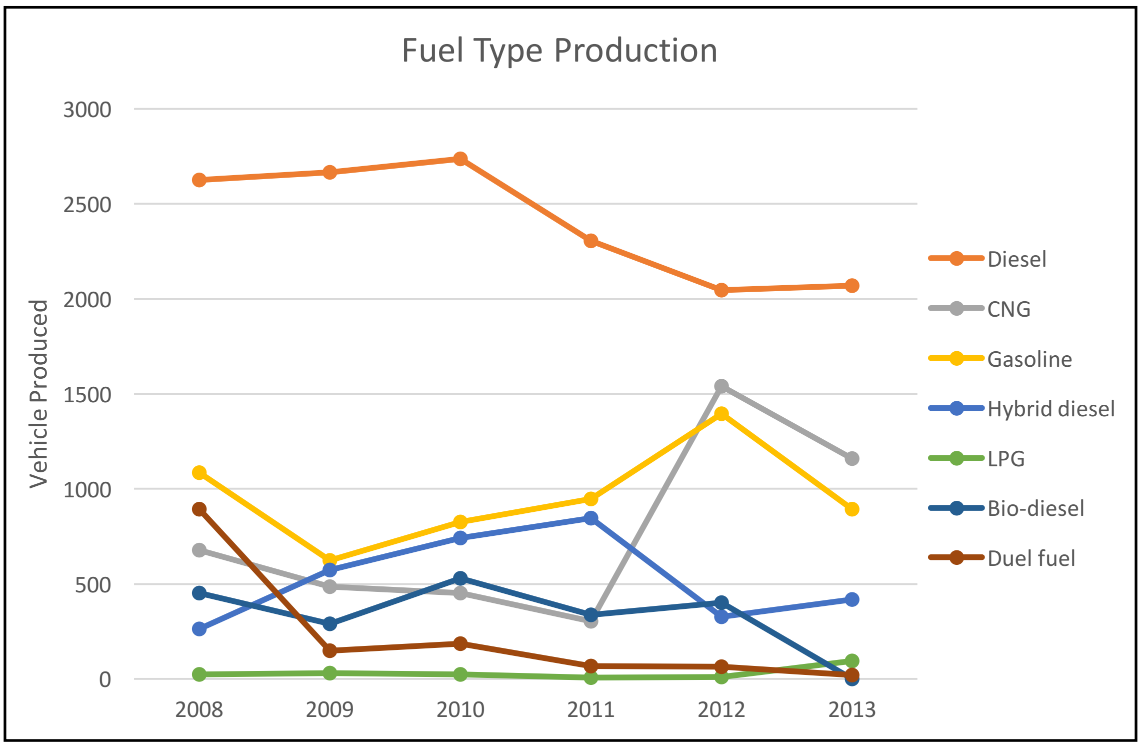

Figure 6. Bus Production 2008 – 2013 by Fuel Type

Source: 2009-2014 National Transit Database.

Diesel

Diesel is the most common fuel type provided by the top four bus manufacturers. Between 2008 and 2013, these manufacturers built 8,884 diesel-powered transit buses. Gillig Corporation manufactured 4,995 diesel-powered transit buses during that period, which is 56% of the total diesel vehicles built by the top four bus manufacturers.

Table 18. Diesel Bus Production 2008 – 2013

Manufacturer	2008	2009	2010	2011	2012	2013
Gillig Corporation	735	981	851	693	775	960
New Flyer Industries	484	276	265	245	263	239
North American Bus Industries Inc.	167	42	301	290	361	252
ElDorado National	43	125	274	28	125	109
Totals:	1,429	1,424	1,691	1,256	1,524	1,560

Source: 2009-2014 National Transit Database.

Table 19. Diesel Bus Production 2008 – 2013 by Manufacturer as Percent of Total

Manufacturer	2008	2009	2010	2011	2012	2013
Gillig Corporation	51.43%	68.89%	50.33%	55.18%	50.85%	61.54%
New Flyer Industries	33.87%	19.38%	15.67%	19.51%	17.26%	15.32%
North American Bus Industries Inc.	11.69%	2.95%	17.80%	23.09%	23.69%	16.15%
ElDorado National	3.01%	8.78%	16.20%	2.23%	8.20%	6.99%

Source: 2009-2014 National Transit Database.

Compressed Natural Gas (CNG)

There had been an increasing production of CNG-powered transit vehicles in 2012 and 2013. In 2013, the production slightly decreased compared to the 2012 production volume, but the production increased significantly in 2012 to three times the level in 2011. Between 2008 and 2010, two major bus manufacturers built CNG-powered buses: New Flyer and NABI. They manufactured 1,118 CNG-powered buses, which is approximately 97% of the total CNG-powered bus production by the top four bus manufacturers. New Flyer built the largest amount of CNG-powered buses annually between 2008 and 2013. Gillig started building CNG-powered buses since 2011 during the six-year period. Now Gillig became the second largest manufacturer of CNG-powered bus in 2013.

Table 20. CNG Bus Production 2008 – 2013 by Manufacturer

Manufacturer	2008	2009	2010	2011	2012	2013
Gillig Corporation	-	-	-	29	116	369
New Flyer of America	259	203	179	166	524	452
North American Bus Industries Inc.	205	130	142	39	311	129
ElDorado National	24	-	11	34	146	87
Totals:	488	333	332	268	1,097	1,037

Table 21. CNG Bus Production 2008 – 2013 by Manufacturer as Percent of Total

Manufacturer	2008	2009	2010	2011	2012	2013
Gillig Corporation	0.00%	0.00%	0.00%	10.82%	10.57%	35.58%
New Flyer of America	53.07%	60.96%	53.92%	61.94%	47.77%	43.59%
North American Bus Industries Inc.	42.01%	39.04%	42.77%	14.55%	28.35%	12.44%
ElDorado National	4.92%	0.00%	3.31%	12.69%	13.31%	8.39%

Gasoline

Gasoline-powered transit buses represent the third largest category in 2013, accounting for 19% of total bus production. The top four bus manufacturers, however, were not the main contributors to the production volume. The major manufacturers of gasoline-powered buses are Glaval Bus (118 buses), Ford Motor Corporation (106 buses), Starcraft (100 buses), Champion Motor Coach Inc. (97 buses), and ElDorado National (86 buses) in 2013.

Table 22. Gasoline Bus Production 2008 – 2013 by Manufacturer

Manufacturer	2008	2009	2010	2011	2012	2013
Gillig Corporation	7	1	0	0	0	1
New Flyer Industries	15	13	31	0	0	0
North American Bus Industries Inc.	0	0	0	0	0	0
ElDorado National	310	42	128	101	95	86
Totals:	332	56	159	101	95	87

Table 23. Gasoline Bus Production 2008 – 2013 by Manufacturer as Percent of Total

Manufacturer	2008	2009	2010	2011	2012	2013
Gillig Corporation	2.1%	1.8%	0.0%	0.0%	0.0%	1.2%
New Flyer Industries	4.5%	23.2%	19.5%	0.0%	0.0%	0.0%
North American Bus Industries Inc.	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
ElDorado National	93.4%	75.0%	80.5%	100.0%	100.0%	98.8%

Bio-Diesel (BD)

As a new energy resource, bio-diesel was introduced to the market recently. The total annual production of bio-diesel powered buses was 399 in 2012. The major four bus manufacturers (Gillig, New Flyer, NABI, and ElDorado National) produced 307 bio-diesel powered buses, which is 77% of the total production. However, there is no explicit record of bio-diesel bus production in 2013.

Table 24. Bio-Diesel Bus Production 2008 – 2012 by Manufacturer

Manufacturer	2008	2009	2010	2011	2012
Gillig Corporation	271	183	261	244	242
New Flyer Industries	40	0	45	0	12
North American Bus Industries Inc.	0	0	0	0	0
ElDorado National	14	0	61	19	53
Totals:	325	183	367	263	307

Table 25. Bio-Diesel Bus Production 2008 – 2012 by Manufacturer as Percent of Total

Manufacturer	2008	2009	2010	2011	2012
Gillig Corporation	83.38%	100.00%	71.12%	92.78%	78.83%
New Flyer Industries	12.31%	0.00%	12.26%	0.00%	3.91%
North American Bus Industries Inc.	0.00%	0.00%	0.00%	0.00%	0.00%
ElDorado National	4.31%	0.00%	16.62%	7.22%	17.26%

Hybrid Diesel

Gillig and New Flyer are the top two manufacturers of hybrid-diesel-powered transit buses. In 2013, they built 389 buses powered with hybrid diesel, which is 93% of the total production.

Table 26. Hybrid Diesel Bus Production 2008 – 2013 by Manufacturer

Manufacturer	2008	2009	2010	2011	2012	2013
Gillig Corporation	60	191	259	174	144	202
New Flyer Industries	100	174	385	353	143	187
North American Bus Industries Inc.	42	100	13	14	10	21
ElDorado National	0	0	0	0	0	3
Totals:	202	465	657	541	297	413

Table 27. Hybrid Diesel Bus Production 2008 – 2013 by Manufacturer as Percent of Total

Manufacturer	2008	2009	2010	2011	2012	2013
Gillig Corporation	29.70%	41.08%	39.42%	32.16%	48.48%	48.91%
New Flyer Industries	49.50%	37.42%	58.60%	65.25%	48.15%	45.28%
North American Bus Industries Inc.	20.79%	21.51%	1.98%	2.59%	3.37%	5.08%
ElDorado National	0.00%	0.00%	0.00%	0.00%	0.00%	0.73%

Liquefied Petroleum Gas

In 2013, liquefied petroleum gas became the fifth major fuel type. ElDorado National and Ford Motor Corporation produced total 87 liquefied-petroleum- gas-powered buses, which is 93% of the total production.

Dual Fuel

Dual-fuel engines are designed to run on gasoline or diesel and natural gas. The total production of buses using dual fuel was 63 in 2012. Gillig Corporation and ElDorado National represented approximately 89% of the total production. Between 2008 and 2012, the production of dual-fuel buses declined from 161 buses in 2008 to 56 buses in 2012. Furthermore, the volume dropped to 10 buses in total in 2013.

Table 28. Dual-Fuel Bus Production 2008 – 2013 by Manufacturer

Manufacturer	2008	2009	2010	2011	2012	2013
Gillig Corporation	108	92	30	59	40	4
New Flyer Industries	30	5	1	0	0	0
North American Bus Industries Inc.	10	0	0	0	0	0
ElDorado National	13	2	25	0	16	6
Totals:	161	99	56	59	56	10

Table 29. Dual-Fuel Bus Production 2008 – 2013 by Manufacturer as Percent of Total

Manufacturer	2008	2009	2010	2011	2012	2013
Gillig Corporation	67.08%	92.93%	53.57%	100.00%	71.43%	40.00%
New Flyer Industries	18.63%	5.05%	1.79%	0.00%	0.00%	0.00%
North American Bus Industries Inc.	6.21%	0.00%	0.00%	0.00%	0.00%	0.00%
ElDorado National	8.07%	2.02%	44.64%	0.00%	28.57%	60.00%

In the next section, the authors explore similar patterns in the demand-response bus manufacturing industry.

DEMAND-RESPONSE BUS MANUFACTURERS

Vehicle Production

According to 2014 National Transit Database, 24 bus manufacturers built a total of 1,139 demand-response buses in 2013. As Table 30 and Figure 7 demonstrate, demand-response bus production has been fluctuating during the six-year period from 2008 to 2013. Compared to its previous year, the total production decreased by 49.56% in 2013. In 2013, the following nine bus manufacturers produced 966 demand-response buses, or approximately 85% of the total demand response bus production:

- ElDorado National
- Coach and Equipment Manufacturing Company
- Champion Motor Coach Inc.
- Glaval Bus
- Ford Motor Corporation
- Goshen Coach
- Starcraft
- Elkhart Coach
- Startrans

Table 30. Demand-Response Bus Production 2008 – 2013 by Manufacturer

Manufacturer	2008	2009	2010	2011	2012	2013
ElDorado National	320	129	296	117	232	174
Coach and Equipment Manufacturing Company	69	59	27	181	88	155
Champion Motor Coach Inc.	14	24	49	53	107	120
Glaval Bus	50	34	72	73	184	107
Ford Motor Corporation	396	355	474	25	35	104
Goshen Coach	91	192	71	135	152	90
Starcraft	112	16	27	104	244	87
Elkhart Coach	0	0	98	69	113	68
Startrans	224	65	45	189	241	61
Others	316	556	275	335	343	173
Total:	**1,592**	**1,430**	**1,434**	**1,281**	**1,739**	**1,139**
		75.95%	-50.54%	21.82%	2.39%	-49.56%

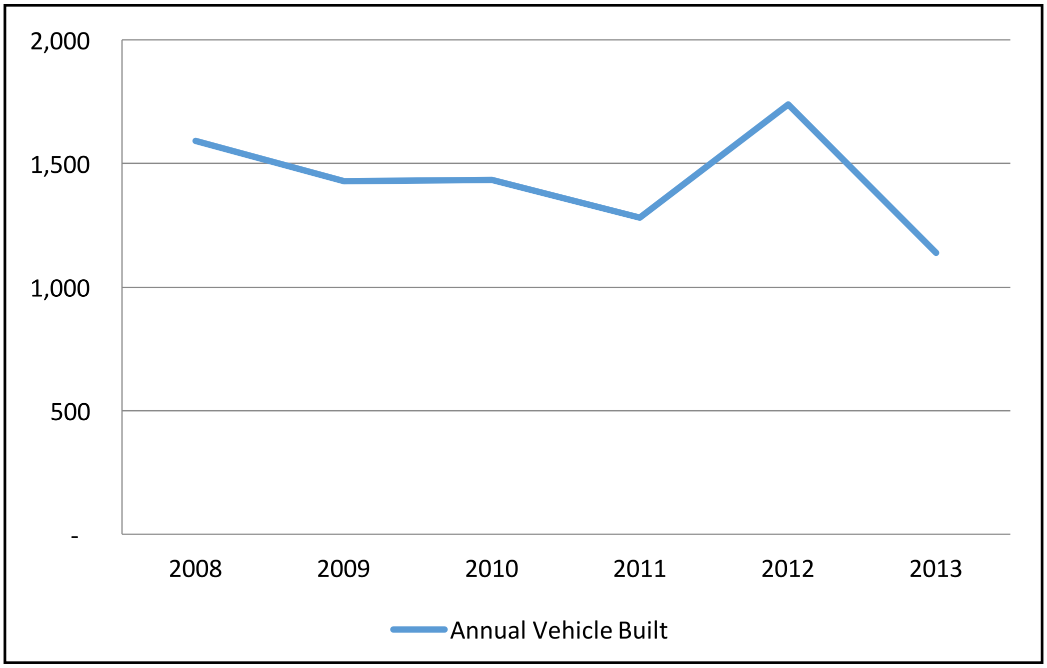

Figure 7. Demand-Response Bus Production 2008 – 2013

Source: 2009-2014 National Transit Database.

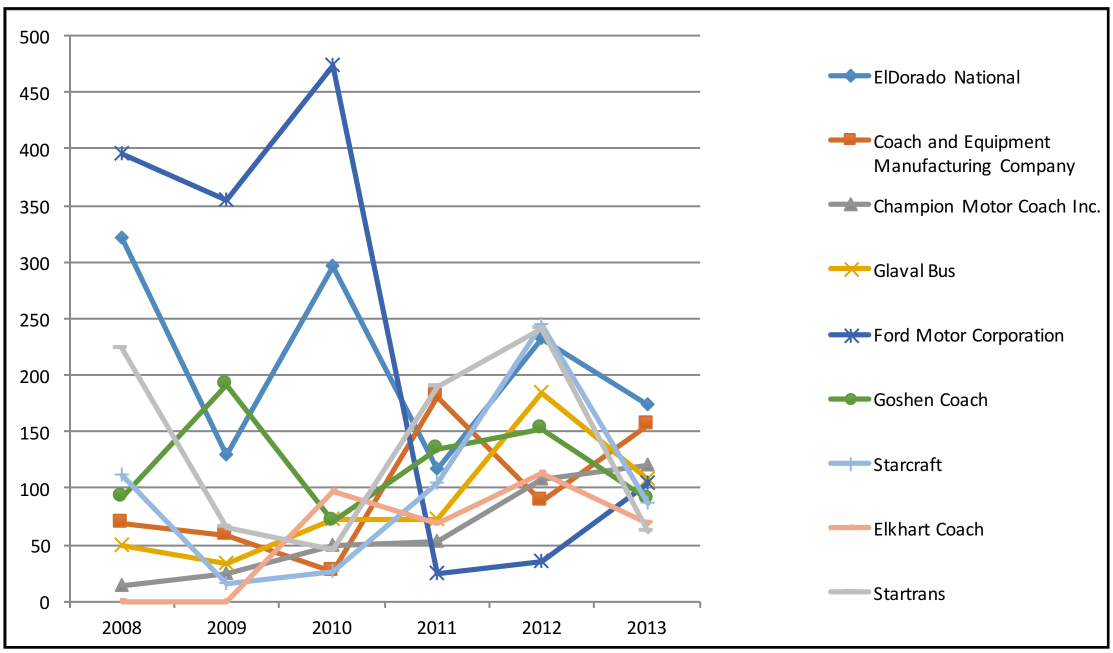

Figure 8. Demand-Response Vehicle Production by Manufacturer 2008 – 2013

Source: 2009-2014 National Transit Database.

As shown in Figure 6, ElDorado National built the largest number of demand-response buses in 2013 – a total of 174 buses, representing approximately 15% of the total demand-response bus production that year. Coach and Equipment Manufacturing Company was the second in terms of bus production in 2013, followed by Champion Motor Coach Inc., Glaval Bus, Ford Motor Corporation, Goshen Coach, Starcraft, Elkhart Coach, and Startrans.

Most demand-response bus manufacturers experienced production decreases in 2013. The production of only three bus manufacturers (Coach and Equipment Manufacturing Company, Champion Motor Coach Inc., and Ford Motor Corporation) increased in 2013 from 2012.

INDUSTRY STATUS

Over the past twenty years the US transit bus manufacturing industry has restructured dramatically, through manufacturers entering and leaving the market, mergers, and acquisitions. There are currently three major manufacturers serving the US heavy-duty transit bus market: Gillig, New Flyer, and Nova.

Gillig

Gillig is based in Hayward, CA in the San Francisco Bay Area. It was founded in 1890 as a carriage and wagon manufacturer.[17] Gillig began producing school buses in the 1930s, and this was its main line of business until the 1970s, when it transitioned to transit buses. Since 1991 it has focused on transit buses, though it also serves the airport shuttle bus market.[18] Gillig introduced their first low-floor bus in 1997 and a hybrid low-floor bus in 2002. Their Hayward plant has the capacity to produce 1800 buses annually.[19] Gillig is owned by CC Industries, a privately held conglomerate headquartered in Chicago, IL.[20] Of the three major manufacturers of heavy-duty transit buses, it is the only one that is US-owned. Gillig primarily produces 40-foot, 35-foot, and 30-foot buses. Table 31 shows the 10 largest US transit fleets of Gillig buses.

Table 31. 10 Largest Fleets of Gillig Buses

Agency	Gillig Buses	Percent of Agency's Fleet
Metro Transit (Minneapolis – St. Paul, MN)	672	74%
Port Authority of Allegheny County (Pittsburgh, PA)	556	79%
RTD (Denver, CO)	459	30%
UTA (Salt Lake City, UT)	426	53%
St. Louis Metro	365	96%
VTA (San Jose, CA)	348	77%
TheBus (Honolulu, HI)	336	65%
COTA (Columbus, OH)	299	77%
LYNX (Orlando, FL)	278	60%
NFTA Metro (Buffalo, NY)	277	88%

Source: 2014 National Transit Database.

New Flyer

New Flyer is based in Winnipeg, Manitoba with US manufacturing plants in Crookston, MN, St. Cloud, MN, and Anniston, AL. Although New Flyer is based in Canada, 70% of their sales come from the US.[21] New Flyer was founded in 1930 and produced inter-city buses before entering the transit market in the 1960s. It was purchased by a Dutch bus manufacturer in 1986, bringing Dutch low-floor bus technology to the North American market.[22] New Flyer performs initial production of its Xcelsior line of 35-, 40- and 60-foot buses in Canada and ships them to the US for final assembly. Its MiDi line of 30- and 35-foot buses are manufactured from start to finish at its St. Cloud plant. New Flyer expanded in 2013 through the acquisition of North American Bus Industries (NABI) and continues to operate their plant in Anniston, AL. New Flyer became a publicly traded company in 2005. In 2013 Marcopolo SA, a Brazilian bus manufacturer, bought a 20% stake in New Flyer.[23] Table 32 shows the 10 largest US transit fleets of New Flyer buses.

Table 32. 10 Largest Fleets of New Flyer Buses

Agency	New Flyer Buses	Percent of Agency's Fleet
CTA (Chicago, IL)	1,351	70%
SEPTA (Philadelphia, PA)	1,147	80%
WMATA (Washington, D.C.)	957	62%
King County Metro (Seattle, WA)	948	51%
OCTA (Orange County, CA)	765	58%
MTA (New York, NY	723	16%
MTA (Baltimore, MD)	580	46%
Metro (Houston, TX)	524	41%
MTS (San Diego, CA)	463	84%
Metro (Los Angeles, CA)	427	18%

Source: 2014 National Transit Database.

Nova

Nova Bus is based in Saint-Eustache, Quebec outside of Montreal and also operates a plant in Plattsburgh, NY. Nova has existed since 1993. Nova formerly had plants in Roswell, NM and Niskayuna, NY, which it closed in order to focus on the Canadian market. Nova returned to the US market when it opened the Plattsburgh plant in 2009. Nova is owned by Volvo. Nova produces 40-foot buses and 62-foot articulated buses. Table 33 shows the 10 largest US transit fleets of Nova buses.

Table 33. 10 Largest Fleets of Nova Buses

Agency	Nova Buses	Percent of Agency's Fleet
MTA (New York, NY)	1,249	28%
CTA (Chicago, IL)	552	28%
MBTA (Boston, MA)	110	10%
MTA Bus (New York, NY)	109	9%
Detroit Department of Transportation	98	27%
DART (Dallas, TX)	88	13%
Metro (Houston, TX)	70	5%
CDTA (Albany, NY)	69	26%
Citibus (Lubbock, TX)	43	42%
MATA (Memphis, TN)	42	27%

Source: 2014 National Transit Database.

There are also several major manufacturers who serve the market for small and mid-sized transit buses. Largest among them are ElDorado National, Startrans, and Starcraft.

ElDorado National

ElDorado National produces shuttle buses for a wide range of uses, including public transit. They also produce accessible vans and heavy-duty buses. Public transit agencies use its vehicles for demand-response and fixed-route services. ElDorado National operates plants in Salina, KS, where it produces its light-duty and medium-duty mid-sized buses, and in Riverside, CA. Most of the buses it sells to transit agencies are in the 20- to 30-foot range. These buses use a fiberglass composite body with steel reinforcement. ElDorado National also sells ADA accessible conversion vans under the ElDorado Mobility label. ElDorado National is a subsidiary of Allied Specialty Vehicles.[24,25]

Startrans and Starcraft

Startrans and Starcraft are shuttle-bus manufacturers owned by Forest River, which also manufacturers recreational vehicles and is owned by Berkshire Hathaway. Startrans was purchased by Forest River from Supreme Industries in 2014. Startrans built 1,000 buses in 2014.[26] Starcraft has been manufacturing shuttle buses since 1998 and claims to be “North America’s largest shuttle-bus company.” They also serve the school-bus market.[27] Both Startrans and Starcraft manufacture their vehicles in Goshen, IN.

DEFUNCT MANUFACTURERS

Over the last two decades a large proportion of transit bus manufacturers have left the market. These departures have been attributed in part to over-capacity and unstable federal funding.[28]

Neoplan USA, which had served the US transit market since 1981, closed its plant in 2005 and declared bankruptcy in 2006.[29] It began as a subsidiary of the German bus manufacturer Neoplan Bus GmbH before becoming an independent company using designs licensed from its former parent company. Neoplan USA’s bankruptcy was precipitated by the federal government’s long delay in passing transportation funding.[30]

Flxible went bankrupt in 1996. It had been making transit buses since 1953 and went through several ownership changes. It was based in Delaware, OH. At one time it was the largest transit bus manufacturer in the US.[31]

Transportation Manufacturing Corporation (TMC) built transit buses at a plant in Roswell, NM. In 1994 TMC’s parent company, Motor Coach Industries (MCI) sold the plant to Nova Bus. At the time, TMC was described as “ailing,” and the plant was to be closed if a buyer couldn’t be found.[32]

Orion International, a subsidiary of Daimler, stopped taking orders for new buses in 2012 when Daimler decided to leave the North American transit bus market. Orion was founded in 1975 in Mississauga, Ontario and also had a plant in Oriskany, NY. Its assets, including its parts and service departments, were bought by New Flyer.[33]

As mentioned previously, New Flyer purchased NABI in 2013. NABI was created in 1992, and was originally named American Ikarus, Inc. The buses it manufactured were partially completed in Hungary before being shipped to the US for final assembly at the NABI plant in Anniston, AL.

Perhaps the turnover of bus manufacturers is best illustrated by Table 34, which shows the number of buses currently being operated that were built by manufacturers that are either defunct or no longer exist as independent companies. These buses comprise approximately 26% of the urban US transit bus fleet.

Table 34. Buses in 2014 US Transit Fleet from Defunct/Acquired Manufacturers

Manufacturer	Buses	Manufacturer Status
North American Bus Industries	7,788	Purchased by New Flyer in 2013.
Orion Bus Industries/ Bus Industries of America	6,269	Stopped taking orders in 2012. Assets purchased by New Flyer in 2013.
Motor Coach Industries International (DINA)	5,044	Purchased by New Flyer in 2015.
Neoplan USA	1,206	Declared bankruptcy in 2006.
Flexible Corporation	101	Declared bankruptcy in 1996.
Transportation Manufacturing Company	55	Plant sold to Nova in 1994.

Source: 2014 National Transit Database urban operator data.

NEW ENTRANTS

Despite the many companies that have left, recently the transit bus manufacturing industry has seen two notable new entrants into the US market. Proterra and BYD America are new entrants who manufacture battery-electric buses. Although they currently have a relatively small number of buses operating in the US, both manufacturers have been growing. Their distinguishing features are their battery-electric propulsions, though they have brought other innovations to the market as well.

Proterra

Proterra was founded in 2004 in Greenville, SC. It is now headquartered in Burlingame, CA and has manufacturing plants in California and South Carolina. Proterra produces 35-foot and 40-foot buses. The buses use a composite fiberglass body and are equipped with either fast-charge batteries or extended range batteries. The fast-charge batteries use lithium titanate and can be charged in the depot and with quick-chargers installed at the end of a bus route.[34] The advantage of charging at the end of the route is that a bus can carry less weight in batteries yet still operate all day without returning to the depot.[35,36] The disadvantage is that more investment in charging infrastructure is required, since chargers must be installed on every route the fast-charge buses will operate on. Proterra's extended-range batteries use lithium nickel manganese cobalt oxide (NMC).[37] Proterra buses are in use at over one dozen transit agencies across the US, with the largest installation at Foothill Transit in the San Gabriel Valley outside of Los Angeles.[38]

BYD

BYD America is a subsidiary of BYD (Build Your Dreams), a Chinese company that began as a battery manufacturer before moving into the electric vehicle market. BYD makes a wide range of battery-electric vehicles, including transit buses. It currently has two plants in Lancaster, CA – one is a former recreational vehicle plant that BYD renovated to manufacturer buses in. The other is a battery manufacturing plant that supplies batteries for BYD's electric buses and other products. BYD produces 40-foot buses and 60-foot articulated buses. BYD's buses are constructed from a steel frame and an aluminum unibody. The chassis is constructed in China and then shipped to the US where final assembly takes place. BYD is vertically integrated, developing and producing its own batteries and motors. BYD's battery technology uses iron phosphate. The company plans to build around 200 buses at their Lancaster plant in 2016 and had 150 orders booked as of January 2016. Berkshire Hathaway owns a 10% stake in BYD.

Aside from Proterra and BYD, there are several other companies producing battery-electric buses for the US transit bus market.

Complete Coach Works (CCW) is a bus remanufacturer headquartered in Riverside, CA that developed an innovative program to retrofit standard diesel buses to battery-electric. The retrofit includes substantial changes to the bus to reduce its overall weight, including the installation of lightweight seating and flooring. CCW refers to the retrofitted bus as ZEPS, Zero Emissions Propulsion System. ZEPS uses lithium ion batteries. The largest installation is with IndyGo in Indianapolis, IN.[39]

Ebus is an electric bus manufacturer based in Downey, CA. ebus produces 22-foot electric buses and is preparing to produce a 40-foot model. ebus's buses use a composite body. The Company also retrofits existing buses to battery electric.[40]

Motiv Power Systems, based in Foster City, CA produces an electric powertrain that can be used in trucks and buses. They have a plant in Hayward, CA. In partnership with Ameritrans Bus, they produce an electric shuttle bus.[41]

New Flyer, Gillig, and Nova also have electric buses in development.[42] One of the transit agencies the investigators spoke with is currently pilot-testing New Flyer electric buses. Gillig said that they have selected a supplier for the electric components for their bus, and the first bus will be tested on the street soon with Contra Costa Transit.

Interviewee Perspectives

For the most part, the people the researchers spoke with from transit agencies did not express concern that there are only three remaining major manufacturers of 40-foot buses. Several expressed the sentiment that as long as there are at least two manufacturers, the transit industry will be ok. With two manufacturers, the transit agencies can still pit them against each other and ensure competitive prices.

As one interviewee noted, three large manufacturers seems to be the sustainable level for the US transit bus manufacturing industry. When there are more than three, the manufacturers tend to get more aggressive and assertive when bidding. Sore losers in a bid are more likely to protest. Another felt that given the size of the market, the size of the industry seems appropriate. They observed that the entrance of foreign manufacturers is cyclical and depends on favorable exchange rates. This observation is borne out to some extent, as shown in Figure 7. Exchange rates were favorable in 1981 when Neoplan entered from Germany, in 1992 when NABI entered from Hungary, and in 1993 when Volvo, from Sweden, acquired Nova. The interviewee felt that these cycles might not be great for the industry.

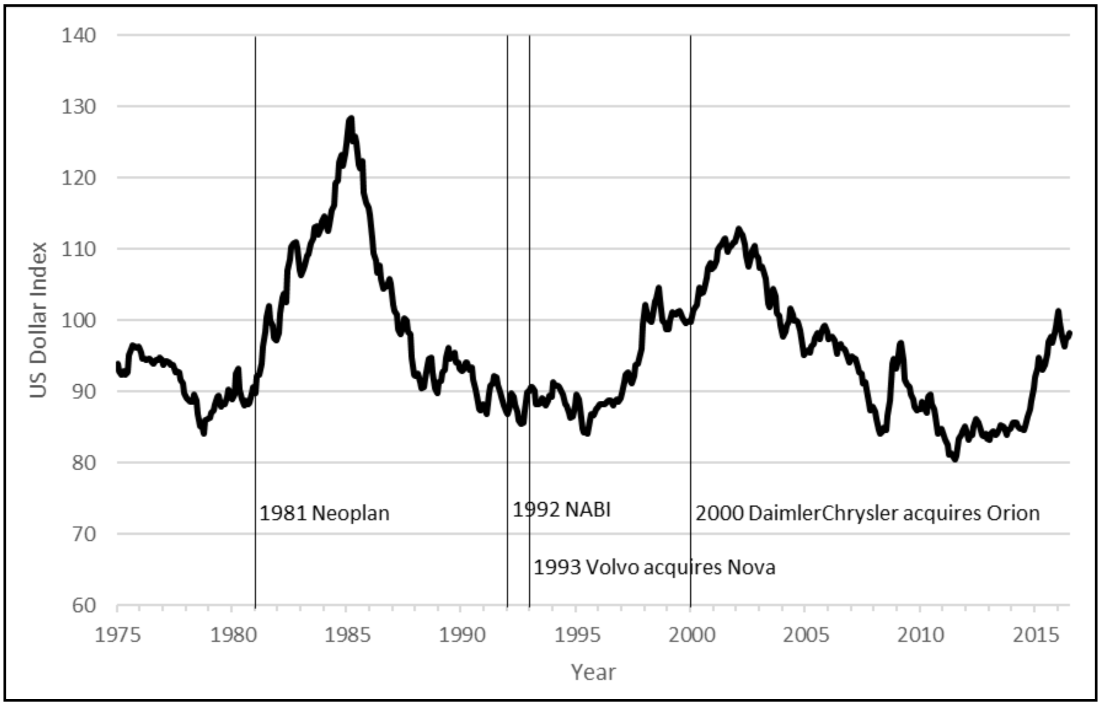

Figure 9. US Dollar Index and European Entry into the US Transit Bus Market

Source: Board of Governors of the Federal Reserve System, Price-adjusted Broad Dollar Index (January 1997 = 100).

An interviewee from a large transit agency said that maintaining competition among manufacturers and suppliers of subsystems is a concern to them. A bus manufacturer procures many major subsystems from vendors, including the engine, transmission, axles, brakes, suspension, doors, seating, flooring, lighting, air conditioning, and fare boxes.[43] The agency strives to make sure there is more than one company qualified for each subsystem of the bus. The interviewee expressed fear that the industry is “small and fragile.” Bus purchase contracts require the manufacturers to be able to supply materials for 12 years after the purchase, but this can be a challenge because of suppliers and manufacturers going out of business. One interviewee expressed concern that there is only one remaining provider of engines for transit buses, Cummins. They pondered the question, “What if Cummins leaves?”

The recent industry restructuring activity has meant that sometimes transit agencies are in the middle of a procurement when the manufacturer is acquired. One interviewee shared their agency’s experience when New Flyer bought NABI. Though the agency was in the midst of taking delivery of a large order from NABI, they said that the acquisition didn’t cause any problems. Through negotiations between the transit agency and New Flyer, the order was assigned to New Flyer. As the interviewee explained, this wasn’t an overall positive or negative – there are certain things that New Flyer can do that NABI couldn’t and vice versa. The last set of buses for the order will be built as New Flyer Excelsiors rather than the NABI model the agency originally procured. The buses will still be built in what was NABI’s Anniston, AL plant.

IV. BUS PROCUREMENT TRENDS

FUNDING

Transit agencies purchase buses with public funds. Funding for public transit comes from a number of sources (Table 35). A transit agency's costs can be categorized into capital costs and operating costs. Capital costs include the cost of buying vehicle, including buses, and infrastructure, such as maintenance facilities. Operating costs cover the day-to-day operation of the service, including wages and fuel.

Table 35. Funding Sources for Public Transit Capital and Operating Expenses, 2014

Funding Source	Capital	Operating
Passenger Fares	---	32%
Other Earnings	---	4%
Directly Generated	23%	7%
Local	21%	23%
State	14%	25%
Federal	43%	9%
Total	100%	100%

Source: APTA 2016 Fact Book Appendix A: Historical Tables.

A transit agency generates revenues through passenger fares and to a lesser extent by activities such as selling advertising space on its vehicles and at bus stops and train stations. These revenues cover about 35% of a transit agency's operating costs. Governments at all levels – local, state, and federal – provide assistance. Local and state transit funding most commonly comes from sales taxes or gas taxes. Some transit agencies are also authorized to levy taxes themselves.

While Table 35 represents the entire transit industry, with all modes of service, the NTD database contains financial data for the 71 urban operators who operate only bus service. An analysis of these operators' funding sources shows them to have a somewhat different breakdown, shown in Table 36. Compared to the entire transit industry, the bus-only providers obtain a larger percentage of their capital funds from the federal government and less from state governments. Local governments provide a larger share of their operating funds than the transit industry as a whole. A number of other factors besides the modes that it operates affect a transit agency's funding sources, including the population of the area it serves, the size of its fleet, and which US state it is in.

Table 36. Funding Sources for Urban Bus-Only Transit Operators, 2014

Funding Source	Capital	Operating
Passenger Fares	<1%	27%
Other Earnings	<1%	2%
Directly Generated	<1%	<1%
Local	30%	54%
State	7%	13%
Federal	62%	3%
Total	100%	100%

Source: National Transit Database.

A 40-foot diesel transit bus costs approximately $500,000. Articulated buses cost close to $770,000 on average, and 30-foot transit buses cost around $420,000.[44] Diesel-electric hybrids and battery-electric buses come at a premium. The FTA provides significant financial assistance for the purchase of buses. FTA funds can be used to cover 80% of the purchase price of a bus. The remaining 20% "local match" can come from local, state, or directly generated funds.

Nearly all transit agencies take advantage of the FTA's assistance for bus purchases. A notable exception is New York City Transit (NYCT), which operates on a larger scale than other agencies. While NYCT does receive funding from the FTA, they allocate it primarily to capital projects on their rail system. Bus purchases are made using funds from the state. As the interviewee explained, purchasing buses in this way gives NYCT some flexibility with their bus purchases, since they aren't subject to the conditions that the FTA stipulates for the use of their funds. For instance, when writing a Request for Proposals (RFP) they are allowed to incorporate a preference for buses manufactured in the state of New York.

The interviewee also explained that NYCT orders such a large volume of buses that they typically divvy up a large order between several manufacturers. This is also an attempt to keep the transit bus manufacturing industry competitive. Going with a single manufacturer could potentially drive other manufacturers out of business. NYCT doesn't want to be in a position where they are reliant on a single manufacturer.

FAST Act

A five-year transportation funding bill, the FAST Act (Fixing America's Surface Transportation Act), was signed into law in December 2015.[45] Prior to that, MAP-21 authorized transportation spending in FY 2013 – 2014, though a truly long-term transportation funding bill hadn't been in effect since SAFETEA-LU, the six-year transportation funding authorization signed into law in 2005 (retroactive to 2004)[46] and that expired in 2009. SAFETEA-LU was extended with a number of short term extensions before MAP-21 was passed.

Under the FAST Act, annual funding for public transit will increase from $10.7 billion to $12.6 billion by 2020.[47] The FAST Act includes a $55 competitive grant program for purchases of low- or no-emissions buses.

Table 37. Annual Transit Funding under the FAST Act

Fiscal Year	Funding ($ Billion)	Percentage Increase (vs FY 2015)
2015	10.7 (Current)	
2016	11.8 (First year of FAST Act)	10%
2017	12.0	12%
2018	12.2	14%
2019	12.4	16%
2020	12.6	18%

Source: American Society of Civil Engineers "FAST Act Summary Part Three: Transit."

The bulk of transit funding comes through Urbanized Area Formula Grants, which provide for capital, operating, and planning assistance. They have been the FTA's primary means of funding public transit since 1984.[48] An urban area's funding is determined by a formula based on population and population density. In larger urban areas, the amount of transit service provided is also a component in the formula. The funds are for urban areas of population at least 50,000. However, for urban areas with a population less than 200,000, the funds go to the state and are spent at the governor's discretion. Urban areas larger than 200,000 receive their funds directly.[49]

Under the FAST Act, Urbanized Area Formula Grants increase from $4.5 billion annually to $5 billion annually by 2020.[50] The FAST Act also creates a Bus and Bus Facility discretionary grant program that will be funded with $268 million in the first year, increasing to $344 by 2020. 10% of these funds are set aside for rural agencies.[51]

The funding carryover decreases from five years to three years under the FAST Act. That is, when a transit agency receives federal funding to procure buses, the funds must be obligated within three years rather than five. Manufacturers the investigators spoke with did not expect this to impact their operations. In a press release, New Flyer expressed the belief that this could result in more frequent procurements with fewer options included in the procurements.[52]

Interviewee Perspectives

Funding Levels

The view commonly expressed among the transit agencies interviewed is that the federal government is not providing enough funding for transit agencies to retire buses in a timely fashion. One interviewee noted that while the federal government has said that they would like to bring the US public transit system up to a state of good repair, they haven't provided enough funding to do so.

Manufacturers said that federal and state funding for bus purchases is crucial to the transit bus manufacturing industry. They would like to see the FTA expand the funding pool. One interviewee expressed the view that manufacturers would also benefit from the US Department of Transportation extending its Transportation Investment Generating Economic Recovery (TIGER) grant program.

One manufacturer said that when Congress doesn't provide long-term funding, it causes a problem for the industry. When funding is only short-term, it creates uncertainty and doesn't allow customers (i.e. transit agencies) to make purchasing plans, because they don't know how much funding they'll have. It can also disrupt production schedules because customers have to cancel orders or change delivery dates.

Frequency of Purchases

Interviewees from transit agencies consistently expressed a preference for smaller, more frequent procurements rather than large, infrequent ones. Procurements that are spread out help the transit agency spread out the demand for maintenance over time, which makes for more manageable workforce planning. As one interviewee explained, all the buses that an agency purchases will need one or two mid-life overhauls. If a large number of buses are purchased at once, then the mid-life overhauls will all come at the same time, and the agency won't have the manpower to handle it.

For example, one agency spoken with was in the midst of taking delivery of an order for 400 buses, with an option for 150 more. The agency structured the delivery so that they received 50 buses at time, then took a break from deliveries for three to four months, before the next batch of 50 buses was delivered. In this manner, the purchase was spread out so that 400 buses wouldn't be due for scheduled oil changes or mid-life overhauls all at once. The interviewee said that in an ideal world, they would have 175 new buses coming in every year to replace older buses. Currently the agency has been under pressure to get their oldest buses off the street, so they have been making larger than ideal purchases as a result.

When bus deliveries are spread out over several years, the contract generally will specify that prices of the buses increase according to an index such as the PPI (Producer's Price Index). This is allowed by the FTA and is important since the manufacturers can't lock in prices from their suppliers that far in advance.

The primary determinant of bus purchases is the availability of government funding. As a result, small and frequent purchases are not the norm. As one interviewee noted, what the federal government is doing wrong is under-funding the bus replacement program. Agencies are not able to replace all of their buses when they reach 12 years of age. Their agency, for example, is running buses until they're 14 years old "without blinking." They noted, though, that their duty cycles are a little lighter than some other agencies. Among all the federal funds that are divided up by their region's transit agencies, there just isn't enough money for every agency to replace its buses every 12 years.

An agency's procurement frequency also depends on its resources. One medium-sized agency spoken with doesn't like to do procurement every year because procurement requires a lot of staff time. Larger agencies, on the other hand, may have a permanent department dedicated to procurement. By procuring new buses every two to three years, the mid-sized agency can constantly renew their fleet. The downside to procuring this frequently in their experience is that they end up with a lot of different configurations of vehicles.

A larger agency said that a “little bit” every year would be nice. The ideal arrangement would be a five- to six-year purchase agreement to replace 10-15% of the fleet every year. That would keep the average fleet age at five to seven years.

STANDARD BUS PROCUREMENT GUIDELINES

The American Public Transit Association’s (APTA) Standard Bus Procurement Guidelines (SBPG) is a model document that transit agencies can use when preparing an RFP for the purchase of new transit buses. The purpose of the SBPG is to improve communication between the transit agencies (the buyers) and bus manufacturers (the bidders). It is a comprehensive document that eases the preparation of an RFP for transit agencies by providing much of the text and technical material that go into an RFP. For example, a bus purchased using federal funds must meet certain requirements, and these federal requirements are all spelled out in the SBPG. By using a standard layout and language, the SBPG makes it easier for the manufacturers to read and respond to RFPs. RFPs produced using the SBPG always contain the same sections in the same order. The SBPG is applicable for buses 30-feet and longer.

The SBPG has its roots in the FTA’s White Book, a standardization effort from the 1970s. The first SBPG, based on the White Book, was produced by APTA in the late 1990s using funding from the FTA.[53] Whereas the original White Book was produced by the federal government, the SBPG was produced by an APTA committee with manufacturers and transit agencies represented on it.[54] As technology changed rapidly with the transition to low-floor buses and the use of alternative-fuel vehicles, the SBPG failed to keep up. The need for an update was voiced at the 2000 Bus Summit, but the guidelines weren’t updated until 2010 in an effort that APTA funded itself through its Standards Development Program.[55,56] APTA plans to continue to update the SBPG every 2-3 years. The most recent revision was released in 2013.[57] An APTA committee comprised of experts from transit agencies, bus manufacturers, and suppliers oversees the updates. Current work is focused on two areas: updating the technical specifications to cover zero-emissions vehicles and revising the terms and conditions sections.[58]

The SBPG consists of 11 sections:

- The Notice of Request for Proposals
- The instructions to Proposers
- The General Conditions
- The Special Provisions
- The Federal Requirements
- The Technical Specifications
- The Warranty Requirements

- Quality Assurance
- Forms and Certifications
- Contract
- Appendixes

Use of the SBPG by a transit agency is voluntary. In a survey of transit procurement managers, Hickman and Jeong found that 84% were aware of the SBPG and 50% said they had used them.[59] Most of those who used the SBPG used only select parts, rather than the full document.[60]

Interviewee Perspectives

Some transit agencies spoken with based their RFPs on the SBPGs, while others developed their own RFPs. Several interviewees said that they use the SBPG as the “backbone” for their RFP and customize it from there. One also said that it is common practice for transit agencies to share their RFPs with other agencies to use as examples when writing their own.

One interviewee explained that it’s not as much the equipment configuration section that helps, but the design requirements, testing, warranty, and level of support sections of the SBPG. The transit industry is unique in that when they buy a bus, they keep it for 12 years. When a trucking company buys a truck, on the other hand, they might keep it for a few years and then sell it as used and buy a new one. To the interviewee, the biggest worry is that the company building the bus is able to sustain it for 12 years.

To mitigate risks, larger transit agencies form a procurement committee to manage the procurement process. The committee will have representatives from across the transit agency, with financial, legal, technical, and operational expertise. Potential lawsuits are one risk that transit agencies seek to mitigate (for instance, from an injured customer or from a bidder who felt there was something improper about the procurement process).

Other concerns are with the health of the bidding company. Will the bidder be able to deliver on its bid? Is it financially sound? Transit agencies want the buses to be as consistent as possible and delivered on time. They want a stable, quality supplier who will be there for them. (Even if a company stops making buses, the FTA requires that they provide parts for a certain number of years beyond that, but in one interviewee’s experience that type of support doesn’t measure up to the support one would get from a company that stays in business.)

When he makes a procurement, an interviewee from a small agency hopes that he ends up with the same equipment that he already has. That makes it easier to maintain. He’d like all his buses to have the same alternator, for example, rather than having to support two or three different alternators. On the other hand, if he ends up with buses from a different manufacturer, then he ends up with all kinds of differences. The bus panels are different, the windows are different, etc. He would like to have a whole fleet of the same type of bus (and hope that the manufacturer doesn’t change things).

One agency said that they do not use the SBPGs because there is state legislation that dictates how they purchase buses, including incentives for buying buses with local content (i.e. manufactured in their home state). When the proposals are evaluated, a bidder's best and final offer is adjusted based on a number of factors, including the use of local content. Examples of other factors are fuel economy and MDBF (Mean-Distance between Failures) of a test fleet.

Another agency doesn't use the SBPG because it is "too convoluted." It has good information in it, the interviewee explained, and the agency's staff may pull things out of it. But the agency's RFP is more tailored to what they want. As the interviewee put it, if you print out the SBPG it's three inches tall while the agency's RFP is an inch tall.

Another agency said that in the past they have not used the SBPG but will seriously consider it for their next procurement, because preparing an RFP requires a large amount of staff time, and the SBPG has the potential to save effort.

One interviewee who has worked both on the transit agency side and the manufacturing side of the industry feels that the industry is using the SBPG more often. He pointed out, however, that there are still reasons for altering the specifications for local needs. More often, the SBPG is altered in the Terms & Conditions section. For example, one agency might require a 10% bond, while another requires a 100% bond. The interviewee said that some of this variation seems counterproductive and that the FTA has started giving guidance on appropriate terms and conditions.

An area where another agency said they make extensive customizations has to do with the operator's environment: for example, the size and location of the seat, and the location and arrangement of switches. The same agency also customizes the warranty, going with longer warranties than in the SBPG, in particular for the engine, drivetrain, and air conditioning. The agency prefers longer warranties because it eliminates its exposure to high maintenance costs, which come out of the operating cost, whereas the warranty is a capital cost. The FTA puts limits on how long a warranty they will fund. The interviewee said that longer warranties meet with resistance because bus manufacturers have a hard time supporting the bus and its components for the two to five years of the warranty.

The manufacturers spoken with all participate on the APTA committee that maintains and updates the SBPG. One interviewee said he considers the SBPG a big help because it brings consistency to the bidding process, making it easier to read and respond to RFPs. Manufacturers still see transit agencies "pluck" only certain sections from the SBPG when preparing their RFPs. They noted that large agencies in particular tend to include commercial terms that are more onerous than those in the SBPG.

The warranties recommended in the SBPG are shown in Table 38. In a survey of transit agencies, Schiavone found a high percentage using the warranty specifications from the SBPG.[61] For the complete bus, 70% used the coverage specified in the SBPG; for primary load-carrying members, 79% used the coverage specified in the SBPG; and for other structural elements, 77% used the coverage specified in the SBPG. For the propulsion system, purchasers of hybrid buses were more likely (64%) to request an extended warranty, though the extended warranty was also popular with diesel purchasers (48%). Use of the recommended subsystem warranties ranged from 37% to 57%, depending on the subsystem. Agencies reported that the most common warranty repairs were for the engine, transmission, and air conditioning.

Table 38. Standard Bus Procurement Guidelines Recommended Warranties

Component	Recommended Warranty
Complete Bus	One year or 50,000 miles
Body and Chassis	Three years or 150,000 miles
Primary Load-Carrying Members	12 years or 500,000 miles
Propulsion System	Two years or 100,000 miles (Extended warranty up to five years or 300,000 miles.)
Emission Control System	Five years or 100,000
Other Subsystems	Two years or 100,000

Source: APTA Standard Bus Procurement Guidelines 2013.

SPECIFYING BRANDS IN PROCUREMENTS

Many transit agencies specify that particular components of the bus be made by specific suppliers. In previous studies bus manufacturers expressed frustration with this practice.[62] The drawbacks from the manufacturers' perspective is that this reduces their negotiating power with their suppliers. They are also wary of using unproven components that could cause problems over time.

The transit agencies the investigators spoke with provided several reasons for specifying some components. One agency specifies that their transmissions be made by a particular supplier because that supplier has excellent local service, the agency's mechanics are already trained on that supplier's transmissions, and the agency has invested in expensive maintenance equipment particular to that supplier's transmissions. So even if the bus manufacturer could negotiate a better price with an alternate supplier and lower the upfront cost of the bus, overall it would not be cost-effective for the transit agency.

The transit agencies spoken with seemed to be as risk-averse as the bus manufacturers when it came to unproven components. As one interviewee explained, if a transit agency has had good experience with a particular component, it will specify it in its RFP because it is too risky from the agency's perspective to go with an unknown vendor's component. The transit agencies interviewed test out equipment before requesting it in a large procurement. For example, one agency said that if it is considering a new component, it will buy a small number of them directly from the supplier and test them out on its buses for three to four years first.

In the experience of several of the transit agencies spoken with, different manufacturers are more or less conservative about using components specified by the transit agency. The manufacturers generally try to comply with the technical specifications in the RFP. During the "approved-equals" process, before bids are submitted, the manufacturers submit a list of potential deviations from the RFP specifications that they would like to make. The transit agency can either approve or deny these deviations. One interviewee also pointed out that some RFP requirements may have the effect of making particular manufacturers' bids uncompetitive for specific vehicle purposes.

When a transit agency specifies particular customizations in their RFP, there is always some push-back from the manufacturers, said one interviewee. It's an issue of the manufacturer keeping their competitive edge, so they can use their preferred suppliers. For example, with an air-conditioning system, his agency will specify a particular one. A manufacturer will ask for an exception to use a different one, and the agency will say no. The manufacturer might hint that without the exception maybe they won't be able to bid. But in the interviewee's experience the agency always gets competition in the bids.

Low Bid and Best Value

Several interviewees expressed the benefits of the FTA allowing "Best Value" procurement and said that it is being used by more and more transit agencies.

In a best-value procurement, the transit agency awards points for different aspects of the proposal, and then awards the contract to the bidder who earns the most points, which is not necessarily the bidder with the lowest cost. For example, at one agency cost typically counts for 20-30 points out of 100. Points are also given for such things as financial strength, ability to provide ongoing support, track record, client references, and Altoona Test performance. The agency asks for balance sheets, audited statements, etc. to verify the bidders' financial strength.

Another interviewee cited the fact that best-value procurement allows latitude and creativity. His agency had a procurement in which price was 40% of the score and the other 60% went for qualifications, experience, and support. Using best-value allowed the manufacturers to submit concepts that were innovative but might cost more: for example, whether to use a stainless-steel vs. mild-steel chassis. The winning bidder proposed a combination, with stainless steel in the high corrosion areas of the chassis and less-expensive mild steel in the rest, with an emphasis on corrosion protection.

Aside from ensuring a quality bus, one interviewee is a proponent of Best-value procurement because it can be used to help ensure that the agency has as much commonality of components in its fleet as possible, to make maintenance easier. He also pointed, however, that larger agencies have the resources and time to do a best-value procurement. Small agencies "just want a bus," so they write a tighter specification and take the lowest price.

V. POLICIES

Manufacturers of transit buses in the US must comply with a wide range of operational and design regulations. Here the authors discuss the most salient policies and share the interviewees' perspectives on them. Covered are emissions regulations, disabled access, alternative fuel programs, the Altoona Test, pooled purchases and piggybacking, spare ratios, workforce training, minimum useful life, Buy America, and R&D.

EMISSIONS REGULATIONS

The Clean Air Act of 1970 gave the Environmental Protection Agency (EPA) the authority to set and update emission standards for all types of new vehicles and their engines, commonly called "mobile sources." The EPA also uses this authority to limit the greenhouse gas pollution from motor vehicles.

The EPA categorizes buses as heavy-duty highway vehicles. This category includes vehicles that have gross vehicle weight rating (GVWR) of above 8,500 lbs. Heavy-duty transit buses usually have GVWR of over 33,000 lbs., which places them in the Heavy Heavy-Duty Diesel Engine (HHDDE) sub-category.

Vehicles that operate in California need to follow the emission standards set by the California Air Resources Board (CARB) in addition to those set by the EPA. CARB's standards are often more stringent than EPA's standards. Some other states have adopted the CARB standards as well.

Emission regulations have evolved over time:

1970 – Clean Air Act

The first standards were in effect after the creation of the Clean Air Act and EPA.

1977 Amendments to Clean Air Act

Congress amended the Clean Air Act to tighten the emission standards.

1990 Amendments to Clean Air Act

The 1990 amendments to the Clean Air Act set the first emission standards specific to urban buses. The standards applied to 1991 and later model years. The detailed standards for each model year from 1991 to 1998 are shown in Table 39.

Table 39. EPA Emission Standards for Urban Buses, Grams per Brake Horse Power-Hour (g/bhp-hr)

Year	Hydrocarbons (HC)	Total Hydrocarbons (THC)	Non-methane Hydrocarbons (NMHC)	Carbon monoxide (CO)	Oxides of Nitrogen (NOx)	Particulate Matter (PM)
1991	1.3			15.5	5.0	0.25
1993	1.3			15.5	5.0	0.10
1994	1.3			15.5	5.0	0.07
1996	1.3	1.3	1.2	15.5	5.0	0.05*
1998	1.3	1.3	1.2	15.5	4.0	0.05*

**0.05 g/bhp-hr standard is used for certification testing and selective audit testing. For in-use testing, the standard remains at level of 1994, which is 0.07 g/bhp-hr.*

Beginning with model year 1996, the EPA instituted Total Hydrocarbons (THC) and Non-Methane Hydrocarbons (NMHC) standards to bring the EPA and California standards into alignment. California emission standards are shown in Table 40.

Table 40. California Emission Standards for Urban Buses, g/bhp-hr

Year	Non-methane Hydrocarbons (NMHC)	Total Hydrocarbons (THC)	Carbon Monoxide (CO)	Oxides of Nitrogen (NOx)	Particulate Matter (PM)
1991	1.2	1.3	15.5	5.0	0.10
1994	1.2	1.3	15.5	5.0	0.07
1996	1.2	1.3	15.5	4.0	0.05

The EPA 1998 standards applied to model year 1998 through 2003. Applicable standards had to be complied over the useful life of the engine. For urban buses, the useful life was defined as eight years (changed to 10 years later) or 290,000 miles whichever came first.

1997

The EPA adopted new standards for model year 2004 and later, with a goal of reducing NMHC emissions. Changes included a new set of standards for NMHC and Oxides of Nitrogen (NOx). There were two options for engine manufacturers: the total of NMHC and NOx should not exceed 2.4 g/bhp-hr or the total of NMHC and NOx should not exceed 2.5 g/bhp-hr, provided that NMHC not exceed 0.5 g/bhp-hr.

The standards for other emissions remained at the 1998 model year level. Also included in the new standards was an increase in the useful life for urban buses to 10 years or 495,000 miles.

2000

The EPA set new standards for model year 2007 and later heavy-duty diesel engines. The new standards were much more stringent than the previous standards, with limits of NOx:

0.2 g/bhp-hr, NMHC (or NMHCE): 0.14 g/bhp-hr, and PM: 0.01 g/bhp-hr. Limits for CO remained at 15.5 g/bhp-hr.

Of the three changes, the new Particulate Matter (PM) standard would go into full effect starting with model year 2007. The NOx and NMHC standards were phased in between 2007 and 2010. The phase-in was based on a percent of sales basis: 50% from 2007 to 2009, and 100% for 2010 (meaning all the 2010 model engines must meet all the required standards).

2011

In 2011, the EPA and Nation Highway Traffic Safety Administration (NHTSA) announced a program aimed at reducing Greenhouse Gas (GHG) emissions and improving the fuel efficiency of heavy-duty trucks and buses. Under this program, the EPA's final GHG emission standards would be in effect starting with model year 2014. The NHTSA's final fuel consumption standards for diesel engines would be voluntary in 2014, 2015, and 2016 and mandatory starting in 2017. Based on the new standards, a 2017 bus (as part of the heavy-heavy category) must meet the two following requirements: useful life CO2 emissions should not exceed 222 g/ton-mile, and fuel consumption should not exceed 21.8 gallon/1,000 ton-mile.

Three emission control technologies have been introduced by engine manufacturers as a result of the increasingly stringent emissions standards. Selective Catalytic Reduction (SCR) and Exhaust Gas Recirculation (EGR) are used to reduce NOx emissions, and Diesel Particulate Filters (DPF) are used to limit PM emissions.[63,64,65] Some of these systems require the engine to run at high temperatures to keep from getting clogged. High temperatures are easy to achieve in applications such as trucking in which the vehicle runs on the highway at high speeds, but can be more challenging for buses, which in many operating environments never achieve high speeds. In such cases, the cleaning can be performed in the depot by running the bus's engine at high RPM while parked.[66,67]

Interviewee Perspectives

All of the transit agencies interviewed have been affected by the increasingly stringent EPA emissions standards for transit buses. Interviewees noted that among diesel vehicle, the transit bus duty cycle is particularly challenging. A vehicle's duty cycle is a characterization of the fraction of time it spends starting, stopping, accelerating, and cruising. A tractor-trailer, for instance, may accelerate onto the highway and then maintain a constant speed for a large fraction of its journey. By contrast, a transit bus in an urban environment may be repeatedly starting and stopping, accelerating and decelerating due to stops for passenger boarding and alighting, traffic lights, and traffic congestion. The frequent acceleration puts a high level of strain on the engine and creates more emissions than highway cruising. A school bus similarly starts and stops frequently, but only does a couple of commutes in the morning and a couple in the evening. Because of the transit bus's stop-and-start nature, it generally can't generate enough heat for emission control technologies that rely on a high temperature.

Several interviewees said that they have had challenges with the engines that meet the 2013 EPA standards. One agency said that while their engines that meet the 2010 standards are running fine, the engines that meet the 2013 standards are having problems with the Exhaust Gas Recirculation (EGR) valve clogging. The transit agency attributed the problem to the pace at which the emissions standards are being ratcheted up, which they feel doesn't leave the engine manufacturers time to do adequate testing. For this transit agency, the engine manufacturer re-programmed the formulation, but at the time of the interview they were still having trouble getting it right. One engine that was failing frequently was exchanged with the manufacturer for a new one. The interviewee was glad that the transit agency purchased a five-year warranty for the engines.

As another illustration of the challenges caused by the evolving EPA guidelines, a different agency spoke of a purchase of 1,000 40-foot buses that were delivered between 2006 and 2008. All the buses were procured using the same technical specifications. Because of the changing emissions standards, however, the buses have four different engine/emissions packages depending on when they were built. The first set of buses was built under the older rules. The next 250 were built under the new standards, and those were the most troublesome. Then the engine manufacturer worked out a better design of the diesel particulate filter, so buses 800-1,000 are the best operating of the group. At the time of the interview, the agency was figuring out how to do the mid-life overhaul of the buses.

As another interviewee pointed out, though the engine makers have been good about honoring warranties, that doesn't help the rider whose bus breaks down. He feels that the EPA uses transit agencies as a captive audience, with the justification that they are using federal money to buy their buses. So transit emissions standards have been changing five years ahead of the trucking industry. As a result, transit ends up paying a higher cost for unproven technology.

The technology changes have caused some engine manufacturers to leave the transit market, namely Caterpillar and Detroit Diesel. Cummins is the only supplier of engines for the US transit bus market. The Korean manufacturer Doosan was making engines for Compressed Natural Gas (CNG) buses, but it backed out of the market. John Deere and Navistar also tried to enter the market but backed out. Detroit Diesel used to be a major supplier but backed out because of the new emissions standards. As one interviewee explained, the US transit bus market is too small to attract the attention of European engine manufacturers.

A large transit agency spoken with said that bus transit is a tough market for engine makers because of the duty cycle and the warranties. The agency has had problems with Diesel Exhaust Fluid (DEF). Particulate filters have been less of a problem because they've been around a long time. The interviewee observed that the new exhaust systems are as expensive as the engine. With the next round of emissions standards, the agency is expecting "a lot of grief."

DISABLED ACCESS

Since passage of the Americans with Disability Act (ADA) in 1990, transit agencies have been required to make their buses accessible to people with disabilities. At its most general, the ADA as it applies to public transit bus service prohibits discrimination against people with disabilities. For instance, a person with a disability cannot be refused a ride on a bus because it takes them "too long" to board. In particular, bus service must be accessible to people who use wheelchairs.[68]

After the passage of the ADA, the 1990s saw the beginning of a transition from high-floor buses to low-floor buses. To accommodate wheelchairs, the high-floor buses employed wheelchair lifts, which tended to be prone to failure. Low-floor buses could use wheelchair ramps, which have proven to be more reliable.

Interviewee Perspectives

After the initial learning curve for transit agencies, providing accessible bus service has become routine, according to most of our interviewees. As mobility devices evolve, however, so too will the guidelines that buses must meet for accessibility. One interviewee explained that meeting ADA requirements is still an ongoing challenge, mainly because mobility devices are constantly evolving. For example, electric wheelchairs can be heavy and exceed the weight limits of a bus's ramp. One agency had two types of ramps on their buses – one with a gentler slope but two pivot points and another with a steeper slope but only one pivot point. Customers complained about the ramps with two pivot points, so the agency is replacing them. Designing a ramp is a challenge from an engineering perspective because a bus can encounter a range of curb heights.

Another perspective an interviewee expressed is that the ADA regulations have leveled off. Before that, they were changing rapidly for a while. This interviewee too said that loading new mobility devices on buses is a problem – "some can be as big as a hospital bed." But they felt that the newest ADA regulations have addressed this and made life easier for transit agencies by specifying what types of devices have to be accommodated – e.g. what turning radius they must have, etc.

ALTERNATIVE FUEL PROGRAMS

In February 2015, the FTA announced the newest round of grantees through their Low or No Emissions (LoNo) Vehicle Deployment Program. The $55.5 million in grants will go to 10 transit agencies in seven states to fund the purchase of vehicles and associated infrastructure, including charging stations. The funds will help purchase 28 battery electric buses built by Proterra; five 60-foot articulated battery electric buses to be developed and built by New Flyer; 10 fuel cell buses built by the team of Ballard Power Systems, BAE Systems, and ElDorado National; and 17 diesel-electric hybrid buses built by Gillig and BAE systems.[69]

Interviewee Perspectives

Several interviewees said that their agencies have used government grants to test alternative fuel buses and shared their experiences.

One agency has four hybrid buses. It is also looking at CNG and plans to buy two electric buses. Currently, in the agency's experience, hybrid buses are expensive to maintain. This agency expects to incur significant costs maintaining the hybrids over their 12-year life, and the grants used to purchase the buses don't cover maintenance costs. (The hybrids also have a higher upfront cost. The agency paid around $660,000 per hybrid compared to $420,000 for a comparable diesel bus.) Over its life, the agency will typically overhaul a diesel bus twice at a cost of $80,000 altogether. The cost of maintaining the hybrids is still unknown, but the agency expects it will be about double that.

Another transit agency has made a large investment in a CNG fleet. The interviewee explained that mechanically CNG buses are much simpler than hybrids. For many years the agency was a proponent of diesel for economic reasons, but in 2009 the natural gas and diesel prices went in the opposite direction and CNG became cheaper. The agency has locked in a CNG price equivalent to a diesel price of $1.29 per gallon, saving them $12 million per year in fuel costs. It has found the maintenance cost differential between CNG and diesel to be negligible.

Another appeal of CNG is that it is a stable technology. As the interviewee explained, there's been no change to CNG engine technology since 2007 when 3-way exhaust catalysts and closed-loop fuel management systems were introduced. One concern about CNG is the added weight due to the fuel tank. The transit agency has been running natural gas buses since the late 1990s and hasn't found any impact on the longevity of the buses due to the added weight.

Cummins, the sole manufacturer of diesel bus engines for the US transit market, also makes CNG engines. According to Cummins, CNG engines account for 25% of the US transit bus engine market, and demand is picking up. In China the growth is more profound, with 40-50% of their buses running on CNG.

On the other hand, one interviewee said that on their agency's most recent procurement it was important to them to have a diesel drivetrain. They don't see the long-term payoff of alternative fuels such as CNG or diesel-electric hybrids. With the latest emissions standard, clean diesel with all the latest emissions technologies is 30-40 times more environmentally friendly than the buses that they are retiring. He considers it a big step up and not too far off from how clean CNG is.

Another reason that an agency spoken with doesn't apply for the FTA grants is that they don't want to purchase a bus with unproven technology and then have to "baby-sit" it for 12 years. The agency might lease electric buses (for three to four years) instead of purchasing them. The interviewee wonders what the industry should do to drive innovation in alternative fuels. He realizes leasing might not necessarily drive the industry and some manufacturers may not be interested, since the manufacturer might not have a use for the buses when they come off lease.

An interviewee at a larger transit agency said that it supports the FTA's work in funding experimental technology. The agency participates because it's important to it that when the FTA tests out new technologies, it include test locations where the technology will be subjected to demanding duty cycles. The agency tested fuel cell buses in the 1990s. It also used an EPA Congestion Mitigation and Air Quality Improvement (CMAQ) grant to test out two different kinds of diesel-electric hybrids, purchasing ten of each. That experiment eventually helped it decide which hybrid technology to go with for a larger purchase.

Another agency has also been involved in testing fuel cell technology, in partnership with other transit agencies in the region. The first-generation fuel cell bus the agency tested was expensive to operate, and it considered the test a failure. It is currently testing two second-generation fuel cell buses, again with neighboring agencies. The inverviewee reiterated that experimental vehicles have high operating and maintenance costs.

One agency has a grant that it's using to buy seven all-electric buses from Proterra. They'll be used on a circulator route. In general, though, the agency tends to stay away from R&D grants – it wants to provide reliable bus service first and foremost. Furthermore, R&D grants usually fund only the initial purchase, not the expense of sustaining the fleet.

Several interviewees noted that the US is behind in terms of battery-electric buses, especially compared to China and even Europe. BYD alone delivered 6,000 battery-electric buses in China in 2015. Battery-electric vehicles are really still in the pilot stage in the US.

One transit agency spoken with is operating two battery-electric buses that it purchased from New Flyer using a federal grant. The procurement process took approximately four years from the time the buses were ordered to the time they were delivered. The agency spent 9-10 months in discussions with New Flyer about exactly what they wanted; then New Flyer spent another 10 months working out the engineering. New Flyer partnered with Siemens for the electrical propulsion system. The transit agency and New Flyer also spent time working out approved equals for some components. The buses had to comply with Buy America, but since the order was for fewer than five buses, the buses didn't have to undergo the Altoona test.

The buses were built in St. Cloud, MN. They were then shipped to Winnipeg during the winter for cold-weather testing, since the transit agency's biggest concern was whether cold weather would adversely affect battery life. The batteries have their own temperature-control system, and the transit agency decided to have a small diesel-powered water heater installed in the bus (roughly the size of a lawn mower engine) that can produce warm water to heat the batteries if necessary.

The transit agency is maintaining the electric buses at one of their depots that also services a fleet of diesel-electric hybrids. As the interviewee explained, the younger mechanics at the garage are more comfortable working with the newer technology buses, which often require hooking up a laptop to the bus to diagnose problems. The agency also installed a charging station in the garage.

New technologies also mean new challenges for the bus maintenance team. One agency with 200 diesel-electric hybrids spoke of its struggles to design the bill-of-materials for the midlife overhaul. The battery packs on the hybrids were the main challenge, while inverters and brushless motors were less of a problem. The batteries were down to 80% efficiency. As the interviewee explained, this is efficient enough for many fixed-location uses (such as the backup power supply for a building) but too inefficient for mobile use (because the bus is essentially carrying around 20% of the batteries as dead weight). New batteries are typically 100% efficient for about four years and then 90% efficient for another two. The agency is trying to determine the after-market for the batteries. The interviewee mentioned that China already has an established secondary market for "80% batteries" because they have a large electric bus initiative.

Another transit agency said that while it was aware of the FTA grants for experimenting with alternative fuels, it decided not to take advantage of them. Particularly with electric buses, it was concerned that there is no standard for charging stations. Every manufacturer has its own proprietary charging system. The agency doesn't want to get locked into a particular manufacturer. Therefore it is waiting for a shakeout of the electric bus market and subsequent emergence of a standard.

A manufacturer echoed this sentiment. His company would like to see the FTA help the industry standardize electric bus charging systems. He worries about transit agencies being locked in to whoever's bus works with their chargers. There is also ongoing uncertainty about on-route charging vs overnight charging. Transit agencies have such diverse operational needs that it might not be reasonable to come up with a single one-size-fits-all solution.

One interviewee explained that a large transit agency faces distinct challenges when experimenting with electric buses because of the charging infrastructure. A small agency, for example, could put electric buses on a single route so infrastructure might not be a big deal. If they then put electric buses on a second route, the second route doesn't necessarily have to use the same infrastructure as the first route. At a large transit agency, operations are more complex, so something like that wouldn't be feasible.

One manufacturer said government grants for alternative fuel vehicles have helped its business. At the federal level, LoNo grants have helped a number of its customers purchase battery-electric buses. In California, the California Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) reduces the cost of purchasing a battery-electric bus so that it is in line with the cost of a diesel-electric hybrid. Another interviewee felt that the LoNo process is overly influenced by politics.

Interviewees suggested several ways in which the government could aid the adoption of battery-electric bus technology. They would like to see the US Department of Energy's (DOE) Advanced Technology Vehicles Manufacturing (ATVM) direct loan program extended to include heavy vehicles. The loan program has benefited battery electric car manufacturers such as Tesla, Ford, and Nissan. Extending it to include heavy vehicles would allow battery-electric bus manufacturers to benefit as well. They would also like to see a change to the alternative fuel excise tax credit, which provides a tax credit for money spent on alternative fuels such as LNG and CNG. Electricity is not included, however, as an alternative fuel that qualifies for the tax credit. The interviewee would like to see electricity included because it would offset transit agencies' electricity costs when adopting battery-electric bus technology. Lastly, another interviewee would like to see the FTA allow agencies to buy electric buses but lease the batteries and capitalize the lease. This way the battery wouldn't be an upfront cost when purchasing a battery-electric bus.

Another area where an interviewee would like to see a policy change is with demand charges. In most states, electric utilities use demand charges to help offset the cost of building infrastructure. A customer incurs a demand charge if their peak 15-minute demand over the course of a month exceeds a certain threshold. As one interviewee pointed out, however, demand charges don't take into account what time during the day the customer's peak 15 minutes occurred. If the peak occurs at night, when overall electricity usage is generally low, then it is not really putting an excess burden on the distribution system. They would like to see demand rate charge policy changed so that if a customer's peak demand occurred during off-peak times they wouldn't incur a demand charge. Since battery-electric buses can be charged overnight, such a change would keep charging from becoming prohibitively expensive.

ALTOONA TEST

Since 1987, buses purchased using federal funds must first have a model undergo a test at the Altoona Bus Research and Testing Center in Altoona, PA. The test covers nine categories: safety, structural integrity and durability, reliability, performance, maintainability, noise, fuel economy, and emissions. The MAP-21 legislation requires that the test provide a "Pass/Fail" result. Work on implementing this change is currently in progress.[70]

Interviewee Perspectives

Generally, interviewees expressed positive opinions about the Altoona Test. One interviewee felt that the testing has led manufacturers to make more reliable buses. Fifteen years ago their agency had a fleet of buses that would go 6-7,000 miles between road calls. Today, their buses are going 22,000 miles between road calls. The entire industry has benefited from the improvement in quality. Another interviewee observed that part of what has helped low-floor chassis designs evolve is that the manufacturers have learned a lot from Altoona testing.

Manufacturers appreciate the Altoona Test for being a "public report card." It allows transit agencies to compare buses on a common basis. One interviewee said that some transit agencies don't take full advantage of the information that the test provides. Manufacturers also said that the test provides them useful information about how their buses wear.

One interviewee pointed out that every category of the Altoona Test has a single test except for the fuel economy category, which has four different fuel economy tests, used for different types of fuel. They would like to see a single fuel economy test applied to all buses so that direct comparisons could be made between different fuel types. Another interviewee would like the Altoona Test to be expanded to include comparative tests on battery performance, safety, and longevity.

Manufacturers expressed a range of opinions on the proposed change to make the Altoona Test "Pass/Fail." For example, one interviewee spoke with a customer who had bought a small fleet of light-duty buses (a type that the interviewee's company doesn't make) and found that they weren't stable when making lane changes. The customer hadn't read the report from the Altoona Test, which indeed noted that the buses didn't have good lane stability. In the interviewee's mind, that should be a pass/fail criteria. Another interviewee felt that while the Altoona Test provides a great forum for an "apples to apples" comparison, it should not be a pass/fail test.

POOLED PURCHASES AND PIGGYBACKING

Some state Departments of Transportation organize pooled purchases as a way to ease the procurement burden for small transit agencies operating in the state. The way such a pooled purchase works is that the state writes a technical specification. Then bus manufacturers respond with prices, including prices for different add-ons. The lowest price bidder who meets the technical specifications wins the contract. A transit agency can then buy vehicles on the contract, treating it as a "menu" from which it selects which size bus and which features they want. All of the buses and add-on features are pre-priced. This is particularly beneficial to small transit agencies that don't have the resources to go through a full procurement. Pooled purchases are also sometimes coordinated by consortiums of transit agencies rather than by state Departments of Transportation (DOTs).

When a transit agency procures buses, it is not uncommon to have one or more options to purchase additional buses beyond the base order. When a transit agency has an option that it doesn't intend to exercise it may assign the option to another transit agency, a practice known as "piggybacking."

Interviewee Perspective

Interviewees related instances when pooled purchases and piggybacking had been beneficial. One transit agency purchased 40-foot buses on a state contract with a neighboring state. From the agency's perspective, the process worked very well. Its home state has a contract, but it's only for light/medium weight vehicles.

One larger agency spoken with was able to benefit from assuming options from other agencies due to fortunate timing. The agency was set to begin an overhaul of one of its rail lines and planned to use articulated buses to provide alternative service while the rail line was closed. Since its existing articulated fleet wasn't large enough to meet the additional need, the agency assumed options for articulated buses from two other cities: one where a project had fallen through and another where they didn't have funding available to exercise their option. By assuming the options rather than going through a procurement from scratch, the agency was able to reduce the procurement time by 8-10 months and began taking delivery of the buses in time for the rail line shutdown. As per FTA policy, when assuming the options, the agency was allowed to make minor changes to the design of the buses but no cardinal changes.

SPARE RATIOS

A transit agency's bus fleet includes a number of "spare" buses beyond the number needed to operate during the peak time of day. The FTA limits the spare ratio, the ratio of the number of spare buses to the number of buses operated at the peak time of day, to 20%. One agency said that when you take into account that buses regularly go through scheduled maintenance, or need unscheduled repairs, or are going through inspection the agency has a usable spare ratio of about five percent. Aside from substituting for buses that break down, the spares are used to provide extra service such as for a special event or if a portion of a rail line is closed. However, the interviewee has found that the real bottleneck with providing these services is operators and maintenance personnel, not the availability of buses. The agency has experienced attrition due to a large number of retirements recently.

TRAINING

As workers retire, one interviewee expressed difficulty finding maintenance workers. The interviewee explained that heavy-duty diesel maintenance is not widely taught, and where it is taught it is mainly geared towards truck maintenance, which is very different than transit bus maintenance because of the difference in duty cycles.

One interviewee is involved in an APTA committee looking at making maintenance training more standardized across the nation. One challenge this person encountered is that there are a wide variety of union rules across transit agencies, with a wide variety of different training requirements in their contracts.

MINIMUM USEFUL LIFE

The FTA requires that heavy-duty buses purchased with federal funds have a minimum useful life of 12 years. Some states also have their own minimum life requirements.[71] A study by Booz Allen Hamilton found that the average retirement age for a heavy-duty bus is 15.1 years, with buses most commonly being retired between the ages of 14 and 18 years.[72] The report concludes that:

> …the current 12-year requirement provides a reasonable retirement age minimum for large, heavy-duty vehicle types. This is because the majority of these vehicles are retired in the 6-year period following the service-life minimum, with the average retirement age occurring roughly three years past the minimum (providing a cushion for the early retirement of poor reliability vehicles).[73]

A bus's lifespan is determined by the longevity of its structural elements.[74] As one interviewee explained, other components can be replaced, but when the chassis fails that is the end of the road for the bus. The wear and tear of the transit duty cycle eventually takes its toll – a bus chassis is constantly subjected to strains and stresses whose cumulative effect eventually weakens the chassis. For example, when two crowned roads meet at an intersection, a bus's frame is inevitably subject to torsion.

Over the life of a diesel bus, its drivetrain will typically be overhauled two to three times. At large transit agencies this tends to be done on a scheduled basis, known as a mid-life overhaul, while at smaller agencies the overhauls are done on an as-needed basis. In either case, an overhaul can cost $100,000-$200,000.[75]

BUY AMERICA

Procurement of buses using FTA funding is subject to the FTA's Buy America Requirement (49 CFR 661). The rolling stock procurement provisions of 49 CFR 661.11 mandate that a bus undergo final assembly in the US and that at least 60% of the bus's components, by cost, be of US origin. In turn, a component of the bus is considered to be of US origin if at least 60% of its subcomponents, by cost, are of US origin. In practice, this last requirement means that major bus components such as the engine and transmission must be manufactured in the US. The 60% requirement has been in effect since 1991 as a result of the Surface Transportation and Uniform Relocation Assistance Act of 1987, which started with a 50% requirement that increased to 55% in 1989 before reaching its present 60% level in 1991.[76] Under the FAST Act, the Buy America content requirement is scheduled to increase from 60% US content to 65% US content in 2018 and 70% US content in 2020.

The Booz Allen Hamilton study noted that Buy America may cause manufacturers who build their bus chassis outside the US to "scrimp" on the chassis. Since 40% of the bus (by cost) may be manufactured outside the US, there is resultant pressure to keep the cost of the chassis at or below 40%. This may adversely affect the useful life of the bus.[77]

Interviewee Perspectives

The transit agencies, manufacturers, and suppliers spoken with were generally supportive of Buy America.

One interviewee wished that they would allow exceptions for technologies that are only available overseas. For example, SCR-equipped diesel engines were available in Europe before the US.

Another pointed out the importance of having final assembly take place in the US. His transit agency would have a difficult time doing quality control if the buses were assembled overseas.

One interviewee said that Buy America may be an impediment to electric buses because no environmentally friendly non-toxic batteries are produced in the US. All are produced overseas, mainly in Japan. If the requirement really does increase to 70%, he feels that it should exempt batteries.

RESEARCH AND DEVELOPMENT

Research and Development (R&D) happens throughout the bus manufacturing supply chain. R&D leads to benefits along a number of dimensions including higher performance, increased reliability, and lower costs. Though the transit bus market is small, roughly 40% (by value) of the components of a bus are shared with trucks.[78] The truck market is nearly 100 times larger than the transit bus market, with around 300,000 trucks produced annually.[79] Much R&D driven by the trucking industry trickles down and benefits the transit bus market.

Interviewee Perspectives

The manufacturers met with all invest in R&D. BYD invests heavily in R&D for battery and electric motor technology in their research labs in China. Gillig invested in R&D to improve their production processes. Gillig personnel visited manufacturers all over the world and have a partner in Europe against whom they benchmark. They also do R&D for passenger amenities, driver amenities, and bus reliability.

At Cummins, R&D spending is a function of specific need. It's spread over engine platforms. It includes some customization and tailoring for bus engines. It's done either on an as-needed or planned basis. Since Cummins serves several markets, it's able to leverage the R&D spending across them.

For example, a transit bus engine is broadly the same as a school bus engine. The market for school bus engines is 30,000 per year, again much bigger than the transit market. The main difference is the product mix. In transit, the 9-liter (L) engine is dominant. The 6.7L or 7L engines are also used, but less commonly. In the school bus market, the 6.7L and 7L engines are dominant while the 9L engine is less common.

Cummins also supplies 6.7L engines that can be installed with hybrid drives. The engine needs to be optimized for the hybrid propulsion system, and this does take significant work. The entry into this market was largely driven by transit, and Cummins itself paid for the R&D. Cummins does get government funded R&D projects off and on, but these would have very specific goals.

There is ongoing interest in R&D to reduce the weight of the transit bus chassis. The CompoBus, developed through a federally funded R&D project, had an innovative composite structure. At the conclusion of the project, NABI developed the CompoBus technology and sold two batches of lightweight composite buses to Los Angeles Metro. The 45-foot buses that Los Angeles Metro purchased are lighter than a conventional steel chassis 40-foot bus, despite being five feet longer. The buses proved expensive to produce, though, and NABI never attracted any other customers for it.[80] More recently, Proterra has adopted a fiberglass composite body for its line of battery-electric buses.

In one interesting case, R&D for a new chassis was undertaken by a transit agency itself. Using federal R&D funds, Ride Solutions built two prototype 26-foot buses. The buses were designed specifically for the rural market with “flex” routes in mind – fixed routes from which a bus may deviate to pick up or drop off a demand-response passenger. Among other objectives, the buses were designed to be light, maneuverable, and accessible. The buses have high ground clearance and a low rear-overhang to handle unpaved roads. They can fit five wheelchairs and even handle gurneys (in, for example, emergency response situations).[81]

One interviewee from a transit agency expressed the opinion that bus manufacturers in the US are splitting up a pretty small pie, which limits their ability to do R&D (in comparison to a large market such as Europe, where there could be a production of 30,000 buses from one builder). He feels that in Europe, R&D is stronger.

Another questioned how the transit market can be expected to drive R&D dollars with a market of only 3,000 – 6,000 vehicle per year. He felt it makes more sensefor technology to move from the larger markets to the smaller markets: from automobiles to light truck to heavy truck and finally to transit. He pointed out that federal and state emissions regulations flip this around and put transit on the leading edge of technological change, which turns into the “bleeding edge.”

When asked what types of R&D they would like to see the FTA funding, interviewees offered a number of ideas. They spoke about what they would like to see funded and how they would like to see funding allocated. They also mentioned a number of R&D success stories that have led to improved components on today’s buses.

Reliability and maintenance were a major theme for R&D needs. Several interviewees said they would like to see more maintenance-free solutions. That is, how do you make buses that are less reliant on day-to-day maintenance? For example, improving the suspension and using sealed wheel bearings would drive up the upfront cost of the axle but would be a good investment. There have already been a number of innovations that have reduced maintenance including brushless motors and LED lighting, (though with LED lighting the interviewee said that transit agencies wouldn’t buy them at first because they were too expensive). Door motors have become more reliable with a change in technology. Windshield wipers have become more reliable. Air conditioning has improved because of the use of screw-type compressors, a technology that was developed for another industry and then adopted by transit.

One interviewee said that door systems are a major weak point. They are cycled thousands of times a day. Even though they have improved, they remain one of the highest maintenance components (previously it was brakes, but the incorporation of disc brakes has taken care of that.) Along similar lines, one interviewee would like to see the FTA invest in R&D to improve the longevity of buses, pointing out that longer-lasting buses would drive down the FTA’s costs as well.

Other R&D projects in which interviewees expressed interest are electric vehicles, lighter weight vehicles, and a better look at hybrid technology. One interviewee noted that BAE and Allison are really the only hybrid drivetrain suppliers to transit in the US. In Europe there are some bigger suppliers, such as Siemens, but these big players haven’t gotten into the US market. Another interviewee would like to see the FTA do something to help engine manufacturers enter the transit market, since there’s only one engine supplier right now.

As one interviewee explained, it takes a partnership between suppliers, manufacturers, and a transit agency to test out new components. They would like to see the FTA fund the higher cost of a low-maintenance component in the interest of proving the concept over time.

One interviewee felt that the FTA could do a better job of partnering with the bus manufacturers. They mentioned the roughly $50 million dollars that the FTA invested in the Advanced Technology Transit Bus Project (ATTB) in the 1990s (the project that led to the CompoBus). The project was performed by Northrop Grumman, a defense contractor, rather than any of the transit bus manufacturers. He would rather have seen the FTA give the five major manufacturers at the time $10 million each and ask them to do a specific R&D project with it.

VI. CROSS-INDUSTRY COMPARISON

In this section the investigators look to three industries that have important commonalities with the transit bus manufacturing industry but operate under different regulatory environments. The industries are the motorcoach industry, which manufactures buses used for intercity travel and other purposes; the recreational vehicle industry, which manufactures motor homes on the same 40-foot chassis that transit buses use; and the civil aircraft manufacturing industry, which manufactures aircraft in quantities on the same scale as the transit bus. The researchers find that the restructuring and consolidation in these industries is similar to that which has occurred in the transit bus industry.

THE MOTORCOACH INDUSTRY

The "Big Three" manufacturers in the motorcoach sector include Motor Coach Industries (MCI), Prevost, and ABC/Van Hool.[82] Table 41 shows the total sales data of the Big Three from 2010 to 2014.

Table 41. "Big Three" Motorcoach Sales

	2010	2011	2012	2013	2014
Private	748	1,054	1,209	1,438	1,411
Public	383	349	348	208	355
Total	1,131	1,403	1,557	1,646	1,766
% Change		24%	11%	6%	7%

Source: American Bus Association.

Tables 42 through 45 show a breakdown analysis of Big Three sales data of 45'+, 40'–45', 35'–40', and 30'–35' motorcoach buses. Although the production of 40'–45', 35'–40', and 30'–35' buses has been decreasing, the production of 45'+ buses increased steadily from 2011 to 2014. The steady growth of motorcoaches links directly to the growth of inter-city bus service. For example, the three largest brands (Greyhound Express, Megabus, and Boltbus) all expanded their networks in 2013.[83]

Table 42. "Big Three" 45'+ Motorcoach Sales

	2010	2011	2012	2013	2014
Private	700	1,004	1,161	1,402	1,373
Public	340	258	264	147	337
Total	1,040	1,262	1,425	1,549	1,710
% Change		21%	13%	9%	10%

Table 43. "Big Three" 40'–45' Motorcoach Sales

	2010	2011	2012	2013	2014
Private	13	15	16	10	20
Public	43	89	84	60	18
Total	56	104	100	70	38
% Change		86%	(4%)	(30%)	(46%)

Source: American Bus Association.

Table 44. "Big Three" 35'–40' Motorcoach Sales

	2010	2011	2012	2013	2014
Private	35	35	32	7	3
Public	-	2	-	-	-
Total	35	37	32	7	3
% Change		6%	(14%)	(78%)	(57%)

Source: American Bus Association.

Table 45. "Big Three" 30'–35' Motorcoach Sales

	2010	2011	2012	2013	2014
Private	-	-	-	19	15
Public	-	-	-	1	-
Total	-	-	-	20	15
% Change					(25%)

Source: American Bus Association.

THE RECREATIONAL VEHICLE INDUSTRY

The purposes of this section are to understand the recreational vehicle (RV) industry, draw comparisons between the transit and RV industries, and hopefully conclude to what extent the differences between the two industries can be attributed to the effect of government policies.

The section begins with background and facts about RV industry. The researchers then describe the merging or consolidation process within the RV industry. The investigators will also reveal consumers' purchase motivations, which is an important driving factor for RV industry. The second part of the section focuses on the Recreational Vehicle Industry Association (RVIA) and its various efforts to keep RV industry thriving. We will focus on how it responded to EPA and NHTSA on the regulations on greenhouse gas emissions standards and fuel efficiency standards for medium and heavy-duty engines and vehicles. This might have explained how the RV industry is immune to EPA emission regulations, which is less likely the case in the transit industry.

Background and Facts about the RV Industry

Recreational Vehicle

A recreational vehicle is "designed as temporary living quarters for recreational camping, travel, or seasonal use." These vehicles allow people to travel by road to cook and sleep in comfort. There are different types of RV, including motorhomes which have their own motor power, truck campers which can be mounted, and travel trailer and folding camping trailers that can be towed by another vehicle. Motorhomes are similar to transit buses because both use 40-foot chassis.[84]

The RV Industry

The RV industry has experienced ups and downs during 1978-2012. According to analyst John Roseyear, many small companies marketed their RV products and made steady profits in the past.[85] However, similar to other industries, the RV industry went through a wave of consolidation, which has resulted in a few key players, each of which has several well-established brands. For example, Indiana-based Thor Industries has the famous Airstream brand, Dutchmen, Crossroads RV, Keystone, and the Thor motorhome brand. In fiscal year 2013 Thor reported net income of $152.9 million in fiscal year 2013 on revenue of $3.2 billion.

Another key player is Winnebago, which owns the Itasca motorhome and Sunny Brook trailer brands. Winnebago reported net income of $32.0 million in fiscal year 2013 on revenues of $803.2 billion.

Other players include privately held Allied Specialty Vehicles (which owns several motorhome brands including Fleetwood and Monaco), Jayco, and Forest River (owned by Berkshire Hathaway).

Overall, the U.S. RV manufacturing industry "consists of about 900 companies with combined annual revenue of about $9 billion." There are five major companies - Fleetwood RV, Monaco RV, Thor Industries, Forest River, and Winnebago. The 50 largest motorhome manufacturers were reported to account for nearly all of industry revenue in 2013.[86]

Consumer Purchase Motivations

RVs are a genuinely discretionary purchase product. The RV market is driven by consumers' willingness to spend and by the availability of financing.[87] According to the RVIA's RV Business Indicators,[88] there are multiple reasons for the growth of the RV industry. For example,

- RVs generally support a balanced and healthy lifestyle for consumers
- RV ownership and travel is a great value, financially, physically and emotionally to consumers
- RVs have different uses/functions, including vacation travel, tailgating and travel with pets.

- RVs make more shorter trips close to home (e.g., weekend getaways) feasible
- Benefits from IRS tax deduction
- RV manufacturers are responding to needs of budget-conscious consumers and right-sizing their products.
- Family lifestyle changes continue to spur demand for RVs
- The “Go RVing” advertising campaign was effective in building demand

In fact, “Go RVing” as an industry effort to promote RV purchase is quite successful, as shown in the Harris Interactive survey research. The ad messages that focus on family togetherness and cost saving resonate equally well with potential RV buyers. The survey also revealed favorable attitudes toward the health and wellness benefits of RVing, which may help persuade non-owners to buy.[89]

Below are listed the relatively higher percentages of potential future RV buyers who said that these factors would make them more likely to buy:[90]

- “RVers save 27 to 61 percent on a typical family vacation — 73%
- Couples who RV develop stronger bonds with each other — 68%
- RVing allows you to be more physically active — 67%
- RVing provides an escape from everyday pressure and stress — 65%
- Kids who travel with their families by RV receive educational benefits — 58%
- Travelling by RV reduces exposure to illness and other health risks — 56%”

Role of the Recreational Vehicle Industry Association (RVIA)

The RVIA is the “national trade association representing nearly 300 manufactures and components suppliers producing approximately 98% of all RVs manufactured in the US.” According to the RVIA registration, there are 68 recreation vehicle manufacturers.[91]

The RVIA engages in several major activities to keep the RV industry thriving. First, the RVIA implements an inspection program to audit RV manufacturers’ compliance with the NFPA 1192 RV standard. In addition, the RVIA frequently offers its members a Federal Motor Vehicle Safety Standard (FMVSS) educational program. Below are examples of RVIA member manufacturer compliance standards:[92]

- “2011 edition — NFPA 1192 Standards for RVs — Covers Plumbing, Propane, and Fire & Life Safety

- 2014 edition — ANSI/RVIA Standard for Low Voltage Systems in Conversion & RVS LV standard — Covers 12 Volt Electrical Systems

- 2014 edition — National Electrical Code (NEC) (See Article 551) — Covers 120V Electrical Systems"

Second, the RVIA also maintains conversations with government representatives on state and national legislation affecting the RV industry. As documented on the RVIA web sites, current issues include for example, energy efficiency, franchising, financial or credit restraints, warranties, product liability, licensing, titling and registration procedures, and highway use rules.

Third and finally, the RVIA works with national bodies regarding regulation that affects the RV industry. The national bodies with which the RVIA works include the national Highway Traffic Safety Administration, the Federal Highway Administration and the United State Park Service.[93]

RVIA's Response to EPA and NHTSA

In a response to the proposed joint rule-making to establish greenhouse gas emissions standards and fuel efficiency standards for medium- and heavy-duty engines and vehicles by EPA and NHTSA, the RVIA has made the following comments.[94]

- "EPA must be consistent with the EISA mandate and the January 18, 2010, Executive Order, which calls for regulatory harmonization and eliminate the proposal to include non-commercial vehicles in this rulemaking."

- The growth of the RV industry can be explained by several factors: IRS tax deduction, consumers' lifestyle, advertising campaigns building demands, RV trade association effort (comments to EPA NHTSA and PR effort forming congressional RV caucus).

- Noteworthy are the comments to EPA, where RVIA compared commercial/transit versus non-noncommercial/RV. RV is a discretionary purchase, with a separate economic impact if there is a lack of purchase motivation.

- EPA & NHTSA: Price will increase $1,411 due to this one regulation.

- There will be an increase of about $825 due to other environmental and safety regulations requirements, e.g., NHTSA's proposal to amend FMVSS 119 (New Pneumatic Tires for motor vehicles with a GVWR greater than 10,000 lbs).

These comments focus on comparison between commercial/transit and noncommercial/RV; essentially, RV is a discretional purchase. The rising cost due to this regulation will negatively affect consumers' purchase motivations, which may lead to great job concerns in the RV industry.

RVIA Government Affairs Effort: Two Examples

RVIA members met with over 60 congressional members in 2014 to raise awareness of the RV industry and a few key issues affecting the industry.[95] One of the important issues is the Generalized System of Preferences (GSP) program, which expired on July 31, 2013.

> "For more than three decades, GSP provided duty-free treatment to selected goods imported from more than 130 developing countries. The RV industry is impacted through finished and unfinished wood and fabric-based produced products, the most significant being lauan, a type of strong, flexible wood panel, is used in nearly every RV. The average cost to each RV manufacturer is almost $138,000 per month in increased duties, with some companies experiencing increased costs in excess of $400,000 per month. The RV industry is facing an annual increase of between $24 million and $32 million just on l[a]uan, simply due to the ex-pired GSP program."

Due to this significant increase in production cost, RVIA requested Congress to respond quickly and approve legislation to renew the Generalized System of Preferences, retroactive to its expiration date and for the longest period possible.

Indiana Rep. Jackie Walorski helped promote the Elkhart County Recreational Vehicle Industry Association at home and abroad. She is committed to limiting "the burdens of federal regulations that are crushing small business" and has been working with members of the Congressional RV Caucus to advocate for policies to ensure the healthy growth of the RV industry. Sen. Joe Donnelly and Iowa Sen. Joni Ernst also worked as co-chairs of the RV caucus in the Senate to reduce the impact of Environmental Protection Agency regulations on Indiana's RV manufacturers.[96]

In conclusion, due to the RVIA's effort, the effects of government policies such as EPA emission standards and others have less impact on RV industry than on the transit industry. In addition, RVIA was able to successfully renew the Generalized System of Preferences (which expired on July 31, 2013) through Dec. 31, 2017, with respect to duty-free treatment of selected goods imported from developing countries.

THE CIVIL AIRCRAFT INDUSTRY

Aircraft and automobile manufacturing are both considered technology intensive industries. Relevant to the subject of this report, the authors focus on the civilian aviation industry (non-defense and non-space). The civilian aviation industry consists of commercial (scheduled airlines) and general aviation (all aviation other than military and commercial scheduled airlines).

Boeing and Airbus Group are both the result of significant consolidation within the aerospace industry in the US and Europe, respectively. Boeing includes part or all of other historically well-known aviation companies such as Wright, Curtiss, North American, Rockwell, McDonnell and Douglas.[97]

Table 46 shows the volume of civil aircraft shipment during calendar years 2001-2014. Prior to the beginning of the economic recession in 2008, the number of aircraft shipped annually was relatively steady and high, ranging from around 3,000 to 4,700. However, shipments dropped sharply in 2009 (a 42% decrease from 2008) and 2010 (a further 19% decrease from 2009) and have been growing steadily since. Transit bus production (Table 7), on the other hand, seems to swing both up and down from year to year between 2008 and 2012.

Table 46. US Shipments of Civil Aircraft 2001 – 2015

	Total Shipments	% Change	Commercial Aircraft	Rotorcraft	General Aviation Aircraft
2001	3,572	- -	526	415	2,631
2002	2,904	-18.70	379	318	2,207
2003	2,935	1.07	281	517	2,137
2004	3,445	17.38	285	805	2,355
2005	4,094	18.84	290	947	2,857
2006	4,443	8.52	398	898	3,147
2007	4,729	6.44	441	1,009	3,279
2008	4,538	-4.04	375	1,084	3,079
2009	2,636	-41.91	481	570	1,585
2010	2,135	-19.00	462	339	1,334
2011	2,377	11.33	477	435	1,465
2012	2,605	9.59	601	486	1,518
2013	2,859	9.75	648	596	1,615
2014	2,981	4.27	723	627	1,631

Sources: Aerospace Industries Association and Forecast International.

The difference in the pattern of year-to-year percentage changes may speak to the different impacts of the economic recession on these two industries. Nevertheless, an important similarity between the civil aviation industry and the transit bus industry is that both use backlogs to manage their demand uncertainty. An in-depth understanding of how civil aviation industry manages backlogs may shed light on the transit bus manufacturing industry.

According to the Financial Times,[98] US and European airliner makers together have an order book of close to 12,000 aircraft, representing between 8 and 10 years' production. Up until recently, orders have been outpacing deliveries.[99] The manufacturers are looking to increase productivity through automation and technological innovation.[100] Specifically, Boeing & Airbus use robots to build airplanes, drones to inspect airplanes, and exoskeletons to help employees lift heavy tools. Another technology that aircraft producers have adopted is additive manufacturing (AM) or 3D printing technology. Boeing uses 3D for hundreds of parts on its airplanes, and the use of 3D printing for spare parts could potentially shorten wait times for them.[101]

VII. CONCLUSIONS AND RECOMMENDATIONS

The US transit bus manufacturing industry has gone through substantial restructuring over the last two decades. The quality of buses has continued to improve, and new technologies have been brought to market. Research and development have made buses more reliable and introduced a wide range of alternative fuel strategies. New entrants with battery-electric technology have spurred further innovation.

The industry is heavily regulated, and policy makers can have a profound impact on it. Because of its low volume, it is a fragile industry, and the instability of federal funding has proven a challenge in the past. To ensure a thriving transit bus manufacturing industry that continues to improve the quality of buses, invests in R&D, and best serves the riding public, policy makers should:

- Work to ensure long-term funding. While funding delays seem to be an inevitable part of Congressional politics today, that is not reason for policy makers to ignore the havoc that short-term funding can play on the transit bus manufacturing industry. To the extent possible, policy makers should work to build on the passage of the FAST Act and ensure that long-term funding continues for public transit.

- Think carefully about making transit buses take the lead for clean-air regulations. True, transit buses operate in urban environments where concerns about air quality are particularly acute. When timetables for emission reductions are too aggressive, however, the negative consequences reach all the way to the riding public. Manufacturers and suppliers have to incur increased service and repair costs for problematic emissions control equipment, transit agencies have to deal with the headache of malfunctioning equipment and the resultant fleet downtime, and ultimately the riding public suffers when scheduled service is missed because buses aren't available.

- While transit has been at the vanguard of testing and implementing hybrid, fuel cell, and battery electric vehicles, policy makers should consider the reality that the transit bus market may be too small to effectively spur the R&D required for improved diesel emissions technology. It may be more efficient instead to let the technology trickle down from the larger diesel truck market.

- Continue to support experimentation with and adoption of alternative fuels. Many of the transit agencies interviewed benefited from government funding for alternative-fuel vehicles. These funds, in turn, have spurred R&D across a range of alternative fuel technologies for transit buses. Policy makers should work to ensure such funding continues. Furthermore, work can be done to reduce the long-term liabilities that transit agencies face when purchasing buses with unproven technology. Policies that provide funding for ongoing maintenance of alternative fuel vehicles or that make it easier to retire them prior to 12 years could help overcome the reluctance on the part of some transit agencies to participate in grant programs for alternative fuel buses.

- Facilitate an industry-wide conversation around standardization of battery-electric charging infrastructure. Standards require the cooperation of all stakeholders: suppliers, manufacturers, and transit agencies. Based on expert interviews, it seems unlikely that a single charging standard can meet the diverse needs of transit agencies due to the range of environments in which they operate. Some bus service might be best served by on-route quick charging, while other service might be best served by in-depot charging. If standards could be developed for these two charging strategies, it would help transit agencies overcome the fear of being locked into a single vendor's technology. With standards in place, a transit agency could decide which general charging strategy makes sense for its needs. It could then choose the vendor that best serves those needs today without worrying about whether that vendor will still be the best vendor when the agency makes its next purchase.

- Implement policies so that transit agencies aren't penalized financially for adopting battery-electric technology. Experts indicated a number of policies that may deter the widespread adoption of battery-electric buses. Policy makers should modernize the demand rate charge practice so that charging buses during off-peak times doesn't incur penalties. Policy makers should consider expanding the ATVM direct loan program to include heavy vehicles. Policy makers should remove the bias against electricity in the alternative fuel excise tax credit.

ABBREVIATIONS AND ACRONYMS

ADA	Americans with Disabilities Act
APTA	American Public Transit Association
ATTB	Advanced Technology Transit Bus
ATVM	Advanced Technology Vehicles Manufacturing
BD	Bio-Diesel
BRT	Bus Rapid Transit
BYD	Build Your Dreams
CARB	California Air Resources Board
CMAQ	Congestion Mitigation and Air Quality Improvement
CNG	Compressed Natural Gas
DEF	Diesel Engine Fluid
DOE	Department of Energy
DOT	Department of Transportation
DPF	Diesel Particulate Filter
EGR	Exhaust Gas Recirculation
EISA	Energy Independence and Security Act
EPA	Environmental Protection Agency
FAST	Fixing America’s Surface Transportation
FMVSS	Federal Motor Vehicle Safety Standards
FTA	Federal Transit Administration
g/bhp-hr	Grams Per Brake Horsepower-Hour
GHG	Greenhouse Gas
GSP	Generalized System of Preferences
GVW	Gross Vehicle Weight
GVWR	Gross Vehicle Weight Rating
HC	Hydrocarbons
HHDDE	Heavy Heavy-Duty Diesel Engine
HVIP	Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project
L	Liter
LED	Light Emitting Diode
LNG	Liquefied Natural Gas
MCI	Motor Coach Industries
MDBF	Mean-Distance Between Failures
NABI	North American Bus Industries, Inc.
NEC	National Electrical Code
NHTSA	National Highway Traffic Safety Administration
NMHC	Non-Methane Hydrocarbons
NMHCE	Non-Methane Hydrocarbon Equivalent
NMC	Lithium Nickel Manganese Cobalt Oxide

NTD	National Transit Database
NYCT	New York City Transit
PM	Particulate Matter
PPI	Producer’s Price Index
RFP	Request for Proposals
RV	Recreational Vehicle
RVIA	Recreational Vehicle Industry Association
SBPG	Standard Bus Procurement Guidelines
SCR	Selective Catalytic Reduction
THC	Total Hydrocarbons
TIGER	Transportation Investment Generating Economic Recovery
TMC	Transportation Manufacturing Corporation

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ABOUT THE AUTHORS

DAVID CZERWINSKI, PH.D.

David Czerwinski is an Associate Professor in the Department of Marketing and Decision Sciences at San José State University and a Mineta Transportation Institute Research Associate. His research involves the application of techniques from operations research and statistics to problems in the private and public sectors. He previously worked in the Planning Department of the Chicago Transit Authority and as a Senior Associate at Transportation Management & Design. He holds a BS in Mathematical and Computational Science from Stanford University and a PhD in Operations Research from the Massachusetts Institute of Technology.

XU (CISSY) HARTLING, PH.D.

Dr. Xu (Cissy) Hartling is currently an Assistant Professor in the Department of Marketing and Decision Sciences at Salem State University. Prior to joining Salem State University in 2015, she worked as an Assistant Professor in the Department of Marketing and Decision Sciences at San Jose State University for three years and worked as a Postdoctoral Associate at the Center for Transportation and Logistics at MIT for two years. Dr. Hartling received her Ph.D. from the Department of Industrial Engineering at the University of Louisville. Her research interests include sustainable supply chains, corporate social responsibilities, carbon labeling, climate change and environmental policies, transportation and distribution network design.

JING ZHANG, PH.D.

Jing Zhang is an Associate Professor in the Department of Marketing and Decision Sciences at San José State University and a Mineta Transportation Institute Research Associate. Her research focuses on consumer behavior and its relations with marketing communications, high-tech media, globalization and policy issues. She has published articles in academic journals, including the *Journal of Consumer Psychology*, *The Journal of Advertising*, *Psychology & Marketing*, *International Journal of E-Business Research*, and *Journal of International Consumer Marketing*. She served on the Editorial Board of *Journal of International and Intercultural Communication*, and International Editorial Review Board of the *International Journal of E-Business Research*. She holds a BS in Psychology from Peking University, China and a PhD in Communications from the University of Illinois at Urbana-Champaign.

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Funded by U.S. Department of Transportation and California Department of Transportation